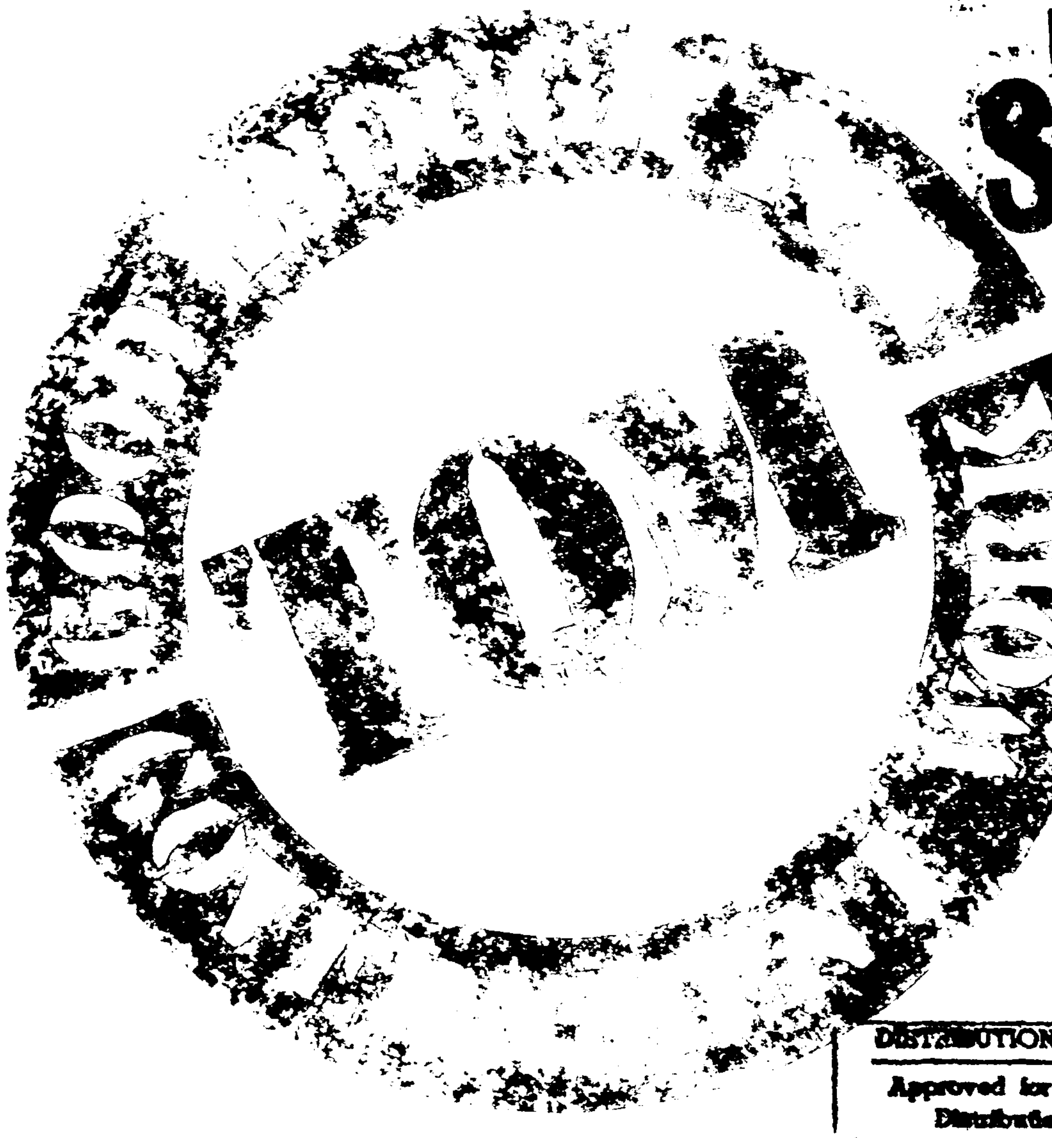
TOTAL QUALITY MANAGEMENT

GOOD ENOUGH FOR GOVERNMENT WORK



A complete guide to the quality movement and principles of TQM as well as a total quality model for transforming an organization.

By Lt Col Mike "Flash" Prowse

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Prowse

Thank you for your assistance

Research Report No. AU-ARI-90-9

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Good Enough for Government Work

by

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For Sue, Mitch, and Miles

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Foreword

While the concept of total quality may be new to many in the Air Force, it is not really new. Dr Walter A. Shewhart's work at Bell Laboratories early in this century may be considered the beginning of the total quality concept. Some have called Dr Shewhart the "father of quality control." Many of his ideas were published by Picatinny Arsenal in the mid-1930s and again in the early 1940s.

Dr George A. Edwards, Dr Shewhart's successor at Bell and who was strongly influenced by Dr Shewhart's work, formed a team at Stanford University to establish inspection techniques for war production during World War II. Among the team members was one W. Edwards Deming who was soon hired by the War Department to teach statistical process control methods to the defense industry. The concepts and methods that he taught were considered so critical that they were classified as military secrets, known as "Z-1" in the US and "Standards 600" in Great Britain.

After the war, most US companies inexplicably stopped using statistical process control. But US occupation forces helped the Japanese to apply quality control methods as they rebuilt their telecommunications industry. Many Japanese scientists, managers, and engineers were so impressed with the results that they formed the Union of Japanese Scientists and Engineers (JUSE), now the most prestigious quality organization in Japan.

When US occupation forces invited W. Edwards Deming to help the Japanese plan and conduct their first postwar census, the JUSE asked him to lecture business leaders on statistical process and quality control. His lectures were so good and so well received that they formed the "genesis of modern quality philosophy."

Another American, Dr Joseph M. Juran, who had "helped out" Edward R. Stettinius, the lend-lease administrator in WWII, taught the Japanese to expand statistical process and quality control methods to all functions in an organization. Dr Juran also taught the Japanese that quality should be defined in terms of customer satisfaction, and the Japanese themselves expanded this concept to include internal customers.

In the United States, nobody seemed interested in total quality until the early 1980s and the concept did not "catch on" rapidly even then, but there has been a significantly increased interest within the past three years. Many US companies have initiated total quality procedures, and many more are currently in the process of implementing total quality cultures.

Both the US Army and the US Navy have adopted the total quality concept, and both have established organizations to promote and assist total quality development. The US Air Force has established the Air Force Quality Center at Air University, Maxwell Air Force Base (AFB), Alabama. Its mission is to provide

commanders and their organizations with advice, concepts, methods, educational resources, and a common frame of reference for attaining a total quality culture.

This publication will contribute significantly to that mission. Its coverage of total quality extensive, its text understandable, this work is a major milestone in the total quality movement. The time for total quality is now.

About the Author

Lt Col Michael J. Prowse

Lt Col Michael Prowse received his undergraduate degree from the University of North Dakota in 1975 and was concurrently commissioned through the Air Force Reserve Officer Training Corps program. He served in various positions as a transportation officer with Air Training Command and United States Air Forces in Europe before his assignment to Air Force Systems Command (AFSC). At AFSC he was the chief of airlift and later worked in the office of the commander.

In 1984 Colonel Prowse attended the Program Manager's Course at Defense System Management College and at graduation was assigned to Electronic Systems Division (ESD), AFSC. At ESD he held positions as the joint surveillance target attack radar system (J-STARS) international program manager, J-STARS director of initiatives, and Air Force Joint Services Imagery Processing System (JSIPS) program director. His work on streamlining was included in the *DOD Streamlining Handbook*.

Colonel Prowse is a graduate of Squadron Officer School (SOS), Air Command and Staff College (ACSC), and Air War College (AWC). He studied advanced transportation at Northwestern University and earned a master of science degree in management from Troy State University.

During the 1989–90 school year, Colonel Prowse attended AWC as the AFSC research fellow at the Air University Center for Aerospace Doctrine, Research, and Education (AUCADRE), Maxwell AFB, Alabama. While at Maxwell, he published an article in the *Air Force Journal of Logistics*, wrote this research report on total quality management (TQM), participated in the writing of a defense analytical study on TQM at program offices, and was a guest lecturer on TQM at ACSC.

Preface

Total Quality Management: Good Enough for Government Work covers the growth of quality from the time of early craftsmen to that of strategic quality management, of which TQM is a part. The first two chapters cover in depth how quality evolved, together with the different programs, techniques, and processes that were developed to solve different problems in the search for quality and high productivity. The second part of the report develops a total quality model based on the work of four well-known quality experts, two leadership experts, and my own knowledge. The total quality model presents 10 elements believed to be fundamental to any organization that pursues total quality: (1) external customers, (2) strategic requirements, (3) strategic vision, (4) mission analysis, (5) organization, (6) supplier, (7) internal process, (8) measurement system, (9) continuous improvement, and (10) direction/feedback loop.

The subtitle of this work, "Good Enough for Government Work," is not intended to slight total quality by implying that it is merely good enough. Anyone who knows the concepts of total quality knows that continuous improvement never allows for "good enough." Rather, the title reflects my strong belief that government employees have failed to provide Americans the service they deserve. Thus, the subtitle is a challenge to all government employees to make their work the standard that all other workers strive to achieve.

MICHAEL J. PROWSE, Lt Col, USAF
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Acknowledgments

This effort really started out as a project *against* TQM. As a matter of fact, the first thesis presented to my research planning group was "Why TQM will not work in a bureaucratic, dictatorial, military-led organization." As you will read in the following pages, I changed my position—quite substantially. I mention this under acknowledgments because I wish to recognize the leadership at AFSC who trusted and allowed me to wander down a road that was counter to the prevailing thought of the day.

One who has never taken on a project of this magnitude cannot begin to appreciate the assistance and work a good research team provides. The team at AUCADRE is a first-class operation. Dr Lewis Ware, my academic advisor, provided a good sounding board throughout the year. Others, such as Dot McCluskie and her production team, were helpful in making sure the product you see here was produced in a quality fashion. My thanks to these people—without this team, this publication would not be.

I want to single out one individual at AUCADRE for special thanks—Preston Bryant. Preston was my editor, and he made my clumsy, awkward ideas sound real and alive, not to mention understandable.

Last, special thanks go to my family—Sue, my wife, and Mitch and Miles, our sons. This was a very special year for them. Not only did they have a husband and father attending Air War College, they had a husband and father who was always too busy at "that darn computer" to take them to the pool, movie, or social events that others were frequenting. There is no way I can make up for a year of extra-long hours, especially in the years ahead, except to express my deepest thanks—everyone should be so lucky as to have such a supportive family.

Introduction

Not a day goes by that does not see at least one newspaper, magazine, or electronic news program making statements critical of the defense procurement system. These criticisms range from poor quality of major new aircraft through faulty inertial navigation systems in cruise missiles to bribery and corruption. Such criticism is not new—it has been going on since the USS *Constitution* was delivered at two and one-half times its contracted cost. There have been countless calls for reform and over 20 different major recommendations since the early sixties, none of which have made a real difference. True to the tradition of bureaucracy, change has been evolutionary and slow—very slow.

One area that offers revolutionary change is in the way we lead and manage our organizations. The concept of strategic quality management was first articulated in the mid-1900s, but it was not fully embraced in our country. Americans were more interested in quantity than quality. Just out of WWII and only a decade away from the Great Depression, American consumers were more than willing to consume in quantity.

At the same time that Americans were buying everything they could find, the Europeans and the Japanese were rebuilding their industrial processes. Japan used the concepts of strategic quality management and *statistical process control* to build the industrial giant we know today. Europe also rebuilt, but on the craftsmanship principle used during the previous two centuries.

This research report is not about the Japanese or the Europeans, however; it is about changing the management foundation principles we operate under. From the late 1800s, American management has operated largely under concepts and principles developed by Frederick W. Taylor. Taylor focused the manager's attention away from the industrial process and toward the planning component. Workers were told what to do, when to do it, and how it was to be done. Managers became removed from quality, workers lost their skills, and quality became another business function like accounting, sales, and industrial service. Now is the time for the United States to accept the advances the Japanese have made, and to move forward.

The management principles discussed in this research report are based on the concept of strategic quality management, which includes TQM. Total quality management is based primarily on the work of four individuals—W. Edwards Deming, J. M. Juran, A. V. Feigenbaum, and Phil Crosby—in the areas of statistics, organizational theory, industrial relations, management, and leadership. But there were others—the influence of Tom Peters, Bob Waterman, H. J. Harrington, and David Garvin can also be seen throughout these pages. These men should be the heroes of the current generation, but seldom are their names mentioned in our schools.

Total quality management covers the entire life cycle of an organization, including the organization's products or services. It is strategic to an organization because it deals not only with the internal environment but also the external environment. TQM goes beyond systems engineering to provide principles of organizational design, leadership, and human engineering. It is the system integrator in an organization, bringing together people, equipment, methods, and machines to effectively satisfy customer expectations. TQM is an organizational culture, a set of norms, and a way to perform the organization's functions.

Total Quality Management: Good Enough for Government Work comprises two basic parts. The first part reviews the quality movement in the US from the time of the industrial revolution up to and including strategic quality management. It will help you understand how quality developed over the years and why particular programs failed.

The second part contains a detailed TQM model. It comprises chapters on these elements: "External Customer," "Strategic Requirements Processing," "Strategic Vision," "Mission Analysis Improvement Cycle," "The Organization," "Suppliers," "The Internal Process," "The Measurement System," "Continuous Improvement," and "Direction/Feedback Loop." These elements represent activities that are crucial to an organization adopting the management principles of TQM.

The title *Total Quality Management: Good Enough for Government Work* was selected to highlight the fact that commitment to quality has become exceedingly rare. It is my hope that this will change. Government employees have the opportunity to initiate a leadership revolution that will set a standard of excellence, and "good enough for government work" should be the highest standard in our land. TQM can provide the touchstone we need to realize this end. The American public deserves nothing less!

Chapter 1

Quality

The quality of a person's life is in direct proportion to their [sic] commitment to excellence, regardless of their [sic] chosen field of endeavor.

—Vincent T. Lombardi

Quality is not new; it has been with us since before Noah was told how to select timber, how to build a boat, and how to satisfy his customers. Noah, and other craftsmen through the ages, knew to look for straight timber that had dense grains and no knots. They knew not to cut too much away from joints because joints wear and can come apart. They knew, when smelting iron ore, not to change the temperature or the iron ore would be inferior. They gained these skills and knowledge the old-fashioned way—trial and error and continuous improvement.

From Noah to the industrial revolution, craftsmanship and quality continuously improved as craftsmen passed on their knowledge to family members and other apprentices. The nineteenth century and the industrial revolution changed craftsmanship in the United States. We entered a new era—one that would forever change mankind. Generally, items would no longer be built one at a time. Mass production allowed the untrained immigrant to succeed in occupations that required knowledge of only a single procedure in the manufacturing process. Craftsmanship was replaced with a central inspection department,[1] due largely to the influence of Frederick W. Taylor, the father of "scientific management."[2] Finally, during the rapid buildup of World War II, the unskilled worker was able to perform repetitive duties with little training.[3]

Taylor, *recognizing that craftsmanship* would be different from that of a century ago, suggested that inspectors should be masters of the tasks they were inspecting. Thus, quality inspection is now a recognized function. Inspectors should have worked their way up the hierarchy, learning the trade better with each step along the way. Knowledge-based craftsmanship was a standard over the centuries, but with manufacturing becoming highly complex, quality had to become specialized. Reliance on the craftsman was replaced with reliance on professionally trained quality experts; quality became a function of management. J. M. Juran, a recognized quality expert, captures this shift very well: "In the days of craft shops, the master . . . participated in the process of managing quality. What emerged [after the industrial revolution] was a concept in which upper management became detached from the process of managing for quality."[4]

The evolution of quality can be divided into three periods: quality engineering, quality assurance, and strategic quality management.[5] It can be tracked through five distinct processes: inspection, statistical quality control, reliability engineering, total quality control,[6] and total quality management. Table 1 provides a visualization of the relationship between the different processes that make up quality and the different periods in the development of quality.

Table 1

Evolution of Quality

PROCESS	PERIOD
Inspection	Quality Engineering
Statistical Quality Control	
Reliability Engineering	Quality Assurance
Total Quality Control	
Total Quality Management	Strategic Quality Management

Quality engineering, which reached its peak in the late 1940s, stressed planning and evaluation. It received most of its innovation and knowledge from the Bell Telephone Laboratories and the Hawthorne Works of the Western Electric Company. This type of quality control worked until the 1950s, when organizations and products became very complex.

Quality assurance forced the development of large data banks for modeling, improving reliability, building reliability into the product, reducing complexity, improving safety, and developing measurement systems.[7] During both these periods, the quality departments of American companies grew larger and further removed from the craft shops of a century earlier.

In strategic quality management, top managers take an interest in quality from the perspective that high quality increases profitability. High quality also provides for a strong perception by the customer—a positive perception that is vital to the success of the company.[8] With TQM, then, we have come full circle. This chapter covers the periods and processes that brought us here.

Quality Engineering

I want to start with a definition derived from A. V. Feigenbaum's *Total Quality Control*. Feigenbaum was more interested in defining quality engineering technology than pure quality engineering. But if we extract the part that addresses technology, the following remains: "analyzing and

planning product quality in order to implement and support the quality system which will yield full customer satisfaction at a minimum cost."[9]

Quality engineering brought quality into the manager's perspective—it recognized the need for quality control. It also recognized that trade-offs could be made to meet customer desires for a level of quality and that quality level is related to product cost. However, the literature does not make it altogether clear that management realized that improvements in quality would reduce waste and thus increase profits.

Quality engineering was the first of the three quality evolution periods. Inspection and statistical quality control comprise the bulk of what most of us think of when we think quality. David A. Garvin, in *Managing Quality*, asserted that the origin of statistical quality control can be traced to W. A. Shewhart's *Economic Control of Quality of Manufactured Product*, published in 1931. Shewhart established the scientific foundation for quality control as well as some techniques for monitoring production. He was the first to suggest ways to improve product and process.[10] He was a member of a prestigious group that included Harold Dodge, Harry Romig, G. A. Edwards, and Joseph Juran. Working at the Quality Assurance Department of Bell Laboratories, this group created statistical quality control and applied it to the massive manufacturing organization of the Bell system.[11] The first process they refined was inspection. Shewhart believed that the quality of the final product was dependent on raw materials, piece parts, and the assembly process. Quality was lacking in a product if variability existed in any of the three elements.[12]

Inspection

Inspection as we know it today came about because it was no longer economical or feasible to compare one part to another or to a master part. The larger quantity and interchangeability of parts required a better system. A key proponent of inspection was the United States Ordnance System, which required munitions that were consistent in effect, usage, and application. On the commercial side, companies such as Singer and McCormick Harvesting began using inspection techniques to ensure conformance and interchangeability. Since these companies were mass-producing their products, their parts had to be interchangeable—and cost was a major factor in the marketability of their product line.[13]

Inspection became formally recognized as a function of quality with the publication of G. S. Radford's *The Control of Quality in Manufacturing*.[14] Radford asserted that inspection was a management responsibility and a function of the quality department. He stated that quality engineers should be involved in the product early in the design process, that quality personnel should be involved across departments for better coordination, and that inspection is a means to increase output while lowering cost. Inspection's purpose was to ensure conformity to established standards. As noted by Radford, "The purchaser's principal interest in quality [was] that evenness

or uniformity which results when the manufacturer adheres to his established requirements."[15] The problem that plagued the inspection process was that when inspectors found problems, nothing was done to correct or prevent them. The recognition by Bell Laboratories that inspection lacked sufficiency drove the development of statistical quality control.

Statistical Quality Control

Statistical quality control has been defined as "the application of statistical techniques for measuring and improving processes."[16] It can be divided into process control and sampling. Relying heavily on statistical methods, statistical quality control began to cause the quality community to move away from the focus of "controlling quality" to that of "measuring and predicting quality." Shewhart captured the essence of process control. He realized that mass-produced parts would vary in dimension, weight, and other characteristics regardless of whether they were made by the same machine or the same person. Shewhart had discovered variability![17] Materials, people, and process would all vary to some degree—not much, but each would be a little different. Understanding this variability between manufactured parts comes from knowing its causes. Variability exists in two distinct areas. The first, unrelated to the design process, includes such things as changes in schedule, new procedures, differing methods, and quality of materials and workers. The second, from the design process, includes procedures and methods, the level and quality of both labor and leadership, and the environment.[18]

Feigenbaum, in *Total Quality Control*, has an excellent section on process control. He concludes that process control tools are just that—tools developed through practical experience by quality engineers at various manufacturing plants, especially the Bell system, to meet differing needs as they arose. These tools became standard practice techniques, were passed around, and were eventually taught to new quality engineering students. These standard practice techniques can be divided into four distinctive categories: process quality analysis, in-process control, quality effectiveness audit, and implementation of the quality plan (table 2).[19]

Table 2

Process Con ·ol Engineering Techniques

Process Quality Analysis	*In-Process Control*
Machine and Process Capability Analysis	Structure Table Control
Quality Measurement Equipment Capability and Repeatability Results	Control Charts
Analysis of Pilot Run Results	Work Sampling
Incoming Material Testing, Inspection, and Laboratory Results	Implementation of the Quality Plan
Nondestructive Test and Evaluation	
Production Testing	Use of Manuals and Standard Instructions
Sorting Inspecting	Interpretation of Drawings, Specifications, and Quality Planning
Process Variation Analysis	

Table 2—*Continued*

Process Quality Analysis	*In-Process Control*
Analysis of Variable Quality Cost Performance Test Data Analysis Field Complaint Analysis	First Piece Inspection Disposition of Discrete or Nonconforming Material
Quality Effectiveness Audit	*Implementation*
To Measure Effectiveness of Product Controlling	Product Audit
To Measure Effectiveness of Quality Planning and Execution	Procedures Audit
To Measure Effectiveness of Quality System and Execution	Quality System Audit
To Measure Effectiveness of Specific Quality Program Areas	Other Areas of Quality Audit

Shewhart was refining his work on process control at the same time Harold Dodge and Harry Romig were working on another, equally important, component of statistical quality control: sampling. Sampling is a way to learn about product quality without having to inspect each item. Decisions to accept or reject are usually based on samples. To reduce error, Dodge and Romig developed sampling plans that predicted the likelihood of inaccurately accepting an unsatisfactory lot.[20] Sampling was a good tool. It allowed the quality department to determine the quality levels of various lots. These levels were then averaged to determine the average outgoing quality limit (AOQL). AOQL allowed manufacturers to determine overall quality and make necessary adjustments. The concept of acceptable quality level (AQL) was then created.[21] A measure of maximum defects, AQL allowed management to provide a "not to exceed" level of defects to the quality department. If AQL was set at zero defects, the customer was assured of getting high-quality parts; if AQL was set at any other level, the customer could get inferior merchandise.

When the AQL was set to a level that allowed some failed parts to be released to the consumer, the producer would pay for repairs either through field service or rework areas in the factory. For failed items that had not been found in the factory, the customer was the final inspector. Sampling 100 percent of the product line can be expensive, especially when customers are relied on to catch what the producers did not.

Manufacturers needed something more than tools that would tell them how good or bad they performed; they needed tools that would help them guarantee the production of quality products. From this need came reliability engineering and total quality control. This period of development, which can be classified as the quality assurance era, started in the early 1950s.[22]

Quality Assurance

In this period, quality moved from being controlled to being coordinated. The process of manufacturing, from beginning to end, was brought under the quality umbrella. Designers and planners alike coordinated their activities to ensure that quality was built into the product.

Reliability engineering was a result of the growing complexity of products, coupled with the military engineering demand that components and systems be reliable.[23] In 1951 Department of Defense (DOD) issued a report, entitled "Reliability of Military Electronics Equipment," by the Advisory Group on Reliability of Electronic Equipment, Under Secretary of Defense for Research and Engineering, that stated, "Only one-third of the Navy's electronic devices were working properly at any given time."[24] This and other examples from the Army and Air Force necessitated a change in the production of quality. Further, Juran made the point that as military contracts became more and more unrealistic in the development time allowed prior to delivery, many tests and procedures normally performed were canceled.

Slight differences exist between various definitions of reliability, but the consensus seems to be with Juran, who views reliability in terms of function, conditions, and time. Juran's definition recognizes three critical points: (1) reliability is only a probability; (2) the conditions of operation must be known; and (3) reliability is measured over a period of time. These three elements form the basis of the reliability movement, forcing the development of tools to assist in measurement and prediction.

Reliability engineering's foundation is the mathematical concept of "probability theory." Three equations designed to predict the distribution of failures have been found to be relatively accurate: the Weibull distribution, which allows for varying rates depending on time, improvements, and deterioration; the exponential life function, which keeps failure rates level throughout product life; and the bathtub curve, which reflects the maturity of the design. The bathtub curve allows for component burn in and failure early in the product's life, a leveling of failure during the productive period, and an increase in the product's later life.[25] Figure 1 reflects the relationship of these three mathematical models. Reliability is reported in terms such as mean time between failures (MTBF) and mean time between critical failures. Critical failure is generally defined as one that prevents mission accomplishment.

Predicting failure was not enough to improve the poor quality found in complex military systems during the early fifties. Needed were more investigative models that would be able to influence the design process "before the rubber ever met the road." Two such tools are failure modes and effects analysis (FMEA) and failure modes and critical effects analysis (FMECA). FMEA is a process that investigates the design, tests failures at each level or opportunity (for failure), looks for causes of component failure, proposes and analyzes alternative designs, de-rates parts (using a higher

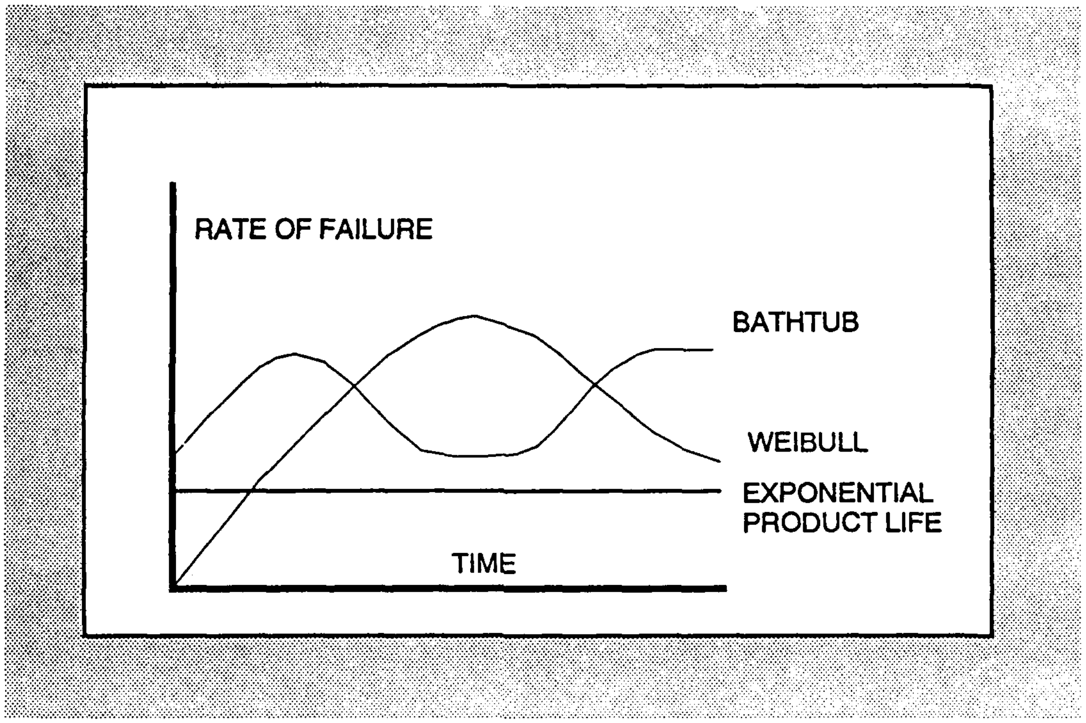


Figure 1. Reliability Models

stress part in a lower stress environment), and estimates the effect of proposed changes.[26] FMECA adds to FMEA a critical analysis that ranks failures by criticality and probability of occurrence.[27] With this data, quality engineers began to have tools and information that helped to improve the design and reliability of the system. Another factor also affected design and reliability—maintainability.

Maintainability is complementary to reliability and they are generally considered together. Whereas reliability engineers look for the causes of failure, maintainability engineers look for the effects of failure. Their goal is to ensure that the design will facilitate a speedy repair. Maintainability is measured in time and referred to as mean time to repair (MTTR). Factors that affect maintainability are size and location of components, frequency of maintenance, and types of items serviced. Together, reliability and maintainability form a critical measure of product quality: availability.

The term *availability*, pushed by the DOD, became an accepted framework for analysis. Availability takes into consideration such elements as repair time, standby for parts, wait time for paperwork, and active use of the product. Availability was viewed as dependent on the product, the environment, and the customer's needs. The design engineer was influenced by the reliability engineer to consider the environment in which the product would work. In the case of spacecraft, where maintenance is generally not available, the design should maximize redundancy and high levels of de-rated components. In the case of aircraft engines, which have

downtimes when components are replaced before their expected failure point, timing standards should be built into the design. Availability was the beginning of a systems approach to quality applied across the product development process.[28] Not unlike reliability engineering, the quality assurance doctrines of product development were being formulated. Manufacturers were concerned with the cost of quality, total quality control, and zero defects.[29]

Strategic Quality Management

The cost of quality was first brought out in *Juran's Quality Control Handbook*. The quality specialist needed to move away from mathematical models to something management could readily understand—cost. Juran pointed out that in any company, most functional organizations sell their function on what it costs the company and what loss of the function would cost.

Another way of looking at quality costs is that they are embedded in the process—"gold in the mine."[30] Looking at quality as gold in the mine allows quality departments to more than pay for the cost of quality. Quality costs are usually categorized into four divisions: prevention (for planning and education), appraisal (for inspection and evaluation), internal failures (to scrap, rework, and repair), and external failures (for warranty, field service, and liability).[31] These divisions are further broken down in the next section. In *Juran's Quality Control Handbook*, Juran makes the point that many quality shops justified increased expenditures by claiming that these expenditures would have a positive rate of return. Once management accepted the notion that quality incurs cost and contributes to return on investment, it was easier to accept the concept of total quality control.

Total Quality Control

The word *total*, as associated with quality, originated with the publication in 1956 of *Total Quality Control* by Armand Feigenbaum. He proposed that product development, manufacturing, marketing, shipping, and other divisions of the organization were just as responsible for quality as was the quality engineer. Quality, said Feigenbaum, is everyone's job, horizontally, throughout the organization (fig. 2).[32] Management was willing to accept this view because it continued the fallacy that quality is *everyone else's* job.

Feigenbaum's definition of quality control provides a way to look at product development as a system. He says total quality control is "an effective system for integrating the quality-development, quality-maintenance, and quality-improvement efforts of the various groups in an organization so as to enable marketing, engineering, production, and service at the most economical levels which allow for full customer satisfaction."[33] Notwithstanding this definition, Feigenbaum did believe that

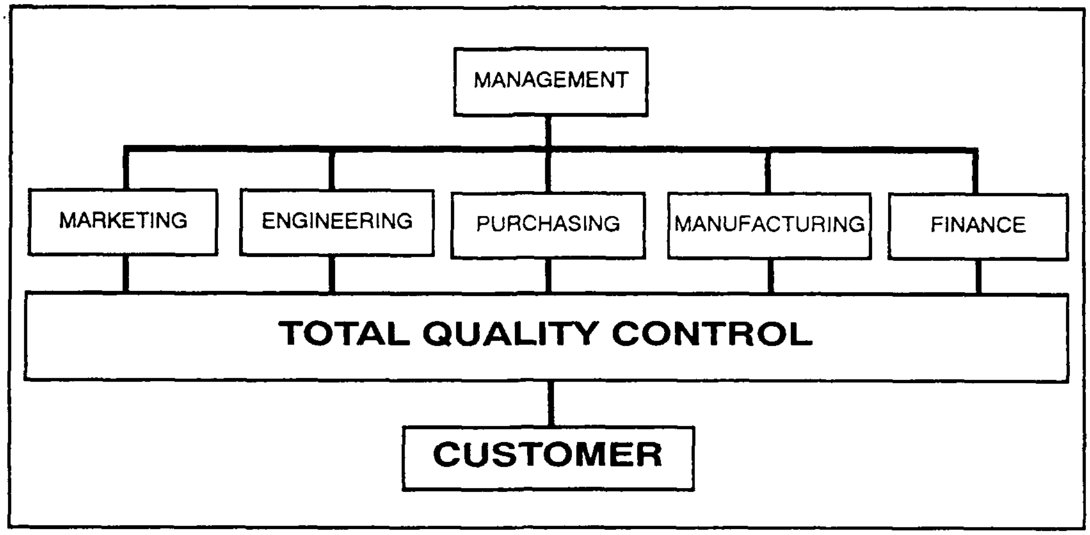


Figure 2. Total Quality Control

management had some responsibility for quality. This is evident in his definition of a total quality system:

> The agreed companywide and plantwide operating work structure, documented in effective, integrated technical and managerial procedures, for guiding the coordinated actions of people, the machines, and the information of the company and plant in the best and most practical ways to assure customer quality satisfaction and economical cost of quality.[34]

The lesson of total quality control is that it is a way of moving the entire company toward customer-oriented quality activities.

In 1984 the Hughes Aircraft Company learned this lesson. After the government stopped accepting Phoenix air-to-air missiles, Hughes management stopped all assembly operations and conducted a thorough audit of workmanship, work instructions, and operating procedures. Quality became the number one priority; other objectives, such as cost and schedule, would fall into line.[35] It worked—quality became the prime responsibility of management and the principal responsibility of marketing, engineering, production, comptroller, industrial relations, planning, and service. All divisions of this integrated organization now work toward the common goal of providing to the customer the quality requested.[36] This was especially costly to Hughes because quality did not receive a high priority until very late in the design and production process. Feigenbaum contends that organizations need to be involved early in the development process to avoid discovering quality problems late, when it costs much more to correct them. In either case, quality must be improved, with the preferred time being "early on and up front" in the manufacturing process.[37]

The overarching concept in total quality control is that quality be viewed as a total system responsibility. Quality must be designed into a product; it cannot be inspected into it. This, then, establishes the fundamental

difference between total quality control and other quality processes—every process in the organization is involved. Feigenbaum stipulates that a total quality system must be capable of meeting the following 13 requirements:

1. Specifically defined quality policies and objectives. It is the responsibility of management to clearly articulate where quality fits in the organization. A quality policy statement that places the importance of quality in the same venue as that of planning, strategy, and corporate priority must be written down for all to see. In addition, the roles and responsibilities of everyone in the company must be documented so that they understand their responsibility in satisfying quality requirements.

2. Strong customer orientation. Every employee in the company must be working toward the common goal of providing the quality desired by the customer at an acceptable price. Each functional area must know and understand customer requirements for operating characteristics, reliability, safety, industry standards, operating cost, and unique features. It is only through the full understanding of all concerned that a proper trade-off between cost and performance on the one hand and the value the customer places on these qualities on the other can ensure customer satisfaction.

3. All activities necessary to achieve quality objectives. Good intentions will not go far if the organization is lacking in quality experts, marketing representatives who understand requirements, or people who can carry out production and service functions in an outstanding manner.

4. Organizationwide integration of quality activities. The company must be viewed as a system, each part working in harmony with the others toward the common objective of satisfying the customer's needs at the lowest possible cost. Systems engineering and systems management processes must be made the most efficient and willing processes in the organization so that it becomes easy to satisfy customer quality requirements in the right way.

5. Clear personnel assignments for quality objectives. All personnel in the organization should have a clear understanding of their responsibility for quality, and they must be informed on actions taken or projected. A good way to document assignments and responsibilities is to develop a relationship chart that lists the areas of responsibility downward and the function or responsible person across the top.

6. Specific vendor control activities. Set high standards and deal only with vendors who are willing to meet or exceed them. Vendors should know without a doubt what the quality requirements are and what to expect when quality is missing from their product or service. Vendors must do all quality checks and certify that quality requirements have been met. A small portion should be sampled to develop a quality data base on each vendor. Send unsatisfactory products back immediately. Develop a continuous improvement program with noncompliant vendors to bring them up to required standards. Always maintain open lines of communication with vendors.

7. Thorough quality equipment identification. Because a total quality system works by integrating the multifunctions, it must have not only the tools it needs to perform quality tasks but also the knowledge to identify new equipment that will assist in measuring compliance. Continuous improvement in quality equipment must be the norm, and it must be budgeted as is any other capital expenditure that contributes to company profit.

8. Defined and effective quality information flow, processing, and control. An effective management information system communicates important quality information clearly and timely throughout the organization. Such a system must be able to document the cost of quality, collect and portray customer concerns, and capture quality information about engineering, production, inspection, and test data. This information must be timely and easily understood by the reader. Ideally, a management information system is operated in real time; that is, as information is acquired, information is loaded into the system. This is easily done with a computer system accessible to everyone in the company. Individuals with decision-making powers in the quality process should have unlimited use of computer resources.

9. Strong quality-mindedness and organizationwide positive quality motivation and training. Positive attitudes constitute the first major objective for a total quality system. Attitude change should be initiated from the top of the organization and go all the way down. Each employee must know without a doubt that quality, craftsmanship, good designs, and outstanding service come before short-term profit. Next, the total quality system should reinforce the skills of the employees so they have all the tools needed. They should know what quality is and what types of quality problems can occur in their particular job. Finally, they should have an understanding of which tools to use and when to use them. The key is organizational commitment to quality and to problem identification. Only through a companywide investment in training will quality continuously improve.

10. Quality cost and other measures and standards of quality performance. Quality cost should be forecast, measured, and tracked through other functional areas. Management should require the total quality control system to track cost in four areas: prevention, appraisal, internal failure, and external failure. Goals should be established to reduce the last two (internal and external failure) while encouraging the first two (prevention and appraisal). Feigenbaum categorized the different quality costs (table 3).[38]

11. Positive corrective action effectiveness. A company's effectiveness in a corrective program is a principal indicator of how well the total quality control system is functioning. Corrective action initiatives must be established to completely and accurately identify the quality problem and to verify its significance to the customer. The corrective action should be permanent.

12. Continuous control of the system, including input, feedback, analysis, and comparison. The total quality control system must continuously measure the pulse of the organization, detect any irregularities, and report quality problems up, down, and across the organization. Standards must be established early, and everyone must know them. These standards should not be compromised lest the integrity of the entire quality system be put at risk.

13. Periodic audit of system activities. The system should be audited regularly to ensure that it can perform as required. These audits should cover the processes, tools, and corrective action capabilities of the system. Functions found to be weak should be corrected immediately. Additionally, the audit should find that specific quality policies are being followed and objectives are being met.

Table 3

Quality Costs

Prevention

Quality planning
Process control
Design and development of quality information system
Quality training and work force development
Product design verification
Systems development and management
Other prevention costs

Appraisal

Test and inspection of purchased materials
Laboratory acceptance testing
Inspection
Testing
Checking labor
Setup for test and inspection
Test and inspection of equipment and material
Quality audits
Outside endorsements
Maintenance and calibration of quality information test and inspection equipment
Product engineering reviews and shipping release
Field testing

Internal Failure

Scrap
Rework
Material procurement cost
Factory contract engineering

External Failure

Complaints in warranty
Complaints out of warranty
Product service
Product liability
Product recall

Thus, total quality control "might be called *total quality management* to cover the full scope of the product and service 'life cycle' from product conception through production and customer service."[39]

Total quality control includes a change in the mind-set of employees and managers. It sets up a system to either prevent or "catch" problems with quality. Total quality control promotes "doing it right the first time," which reduces cost and increases productivity.[40] A slightly different approach was to expect no deficiencies to begin with. This radical approach was tagged "zero defects."

Zero Defects

The zero defects program was born of a realization that if employees had the knowledge to perform the job, and the proper tools and equipment, they needed only the desire and attention to detail to complete the required task without defects. The zero defects program changes employee attitudes about the work they do—and don't do.[41] Zero defects originators recognized that we regularly accept less than perfection in our lives; we are satisfied with less than an "A" on a test, and we accept our children finishing their homework (as opposed to doing it correctly). In short, we accept what James F. Halpin called the "passing-grade complex." But while we accept this less-than-perfect performance from our families and ourselves, we don't accept it from professionals we deal with. We expect our car to be fixed right the first time, we expect the toaster we bought to work, and we expect the doctor to prescribe the proper medicine for our ailments. Zero defects capitalizes on this "double standard," alerting workers to the failure to meet standards and pointing out that someone is getting less than the workers themselves would have accepted. Zero defects requests employees to pledge zero defects in their workmanship.

While zero defects is a psychologically different approach, it nevertheless builds on previous quality improvement and control approaches. Halpin says that zero defects is "a constant, conscious desire to do a job (any job) right the first time" and notes that installation of a zero defects system consists of five steps or processes: (1) presentation of the challenge (to company and workers), (2) management support of the challenge, (3) establishment of clear and unambiguous standards, (4) checking for conformance to standards, and (5) rewarding conformance.[42]

Zero defects worked when it was originated at Martin Marietta during the Army's Pershing missile program in the early 1960s. In his book on zero defects, Halpin says documentation is lacking because zero defects was not envisioned as a universally applied program. In fact, Halpin, the director of quality for Martin Marietta, didn't write his authoritative book until years later. The results of zero defects were beyond believability. Because of this, Martin Marietta was skeptical. Only what could be proven by the company and audited by the Army was reported. Yet, Martin Marietta reported a

savings of $1.6 million and a 54 percent decrease in defects over a two-year period for one-third of its operation in Orlando, Florida.[43]

Similar to, and building on, Feigenbaum's total quality control, zero defects brings management further into the area of responsibility for quality. The system does not make management totally responsible, but it gives managers responsibilities:

1. Managers must understand why they have quality problems, where these problems are, and who or what is responsible.
2. Managers must articulate in general terms what is expected of each function.
3. Managers must constantly support the zero defects program with time and personnel.
4. Managers must constantly acknowledge and reward positive compliance with the zero defects program.[44]

Both zero defects and total quality control insist that quality be viewed as a system that cuts across the entire company; that is, quality is everyone's job. They also insist that employee motivation cannot be ignored if a constant and conscious desire to do a job right the first time is to be the goal. The last major move in the quality movement was the acknowledgment that quality has strategic aspects that can be employed to enhance the company competitively and provide satisfaction to the employees.

Summary

Strategic quality management builds on what management and quality experts have learned in the past.[45] It means more than increasing reliability or improving workmanship—it means getting close to the customer, understanding customer needs, and knowing what engineers can efficiently produce.[46] It fully supports Feigenbaum's total quality control and its accompanying systems application. Previously developed tools, such as those in statistical quality control, are more important than ever. Inspection, process control, sampling, reliability engineering for availability, the cost of quality, and employee motivation are all incorporated in strategic quality management. Additionally, the awareness that quality can be as powerful a competitive weapon as cost, availability, and commitment to the strategic goals of a company is now being incorporated in the company mind-set as, for example, market analysis was previously.

The significance of quality as a vital element of business can be understood better by comparing its formulation with strategy formulation.[47] Both occur at the very top of any organization, and both can cause major changes. Finally, both influence the internal and external processes of the company through the establishment of standards.[48] Both are important to the company's success.

Acceptable quality is no longer the goal; the goal is, rather, continuous improvement.[49] The goal of zero defects—through employees participating with management to solve quality and process problems—and management's commitment to quality philosophy make strategic quality management the most dynamic initiative to be incorporated in business management since the industrial revolution. In *Managing Quality*, Garvin succinctly summarizes a 1983 White House Conference on Productivity report on strategic quality management:

> Managing the quality dimension of an organization is not generically different from any other aspect of management. It involves the formulation of strategies, setting goals and objectives, developing action plans, implementing plans, and using control systems for monitoring feedback and tracking corrective action. If quality is viewed only as a control system, it will never be substantially improved. Quality is not just a control system; quality is a management function.[50]

William F. Roth, Jr., in his article "The Great Shell Game," makes the point that a major misconception in the quality arena is that there is no one "best" approach to improving quality. He contends that there are four approaches: the customer-oriented approach, the manager-oriented approach, the employee-oriented approach, and the technology-oriented approach.[51] Strategic quality management focuses on each of these orientations in a systematic direction. It forces companies and service organizations to look on quality improvement as a long-term process that involves senior leadership, management, and workers at all levels in a continuous process; it is *not* a program that has a beginning, some objectives, and a conclusion.[52]

One major initiative established on the concepts of strategic quality management is DOD's Total Quality Management Program. DOD has played an important role over the years in advancing quality in American manufacturing. TQM continues that trend; it should be well understood by producers, customers, overseers, legislators, and employees. Those who don't understand what is happening may miss the management revolution that will forever change management principles.

Notes

1. J. M. Juran, *Juran on Leadership for Quality: An Executive Handbook* (New York: Free Press, 1989), 4.
2. Frederick W. Taylor, *Shop Management* (New York: Harper & Brothers, 1919), 101.
3. James F. Halpin, *Zero Defects: A New Dimension in Quality Assurance* (New York: McGraw-Hill, 1966), 3.
4. Juran, 4.
5. Ibid., 5.
6. David A. Garvin, *Managing Quality: The Strategic and Competitive Edge* (New York: Free Press, 1988), 1.
7. Juran, 5.
8. Garvin, 21.
9. A. V. Feigenbaum, *Total Quality Control*, 3d ed. (New York: McGraw-Hill, 1983), 234.

10. Garvin, 6.

11. Ibid.

12. W. A. Shewhart, *Economic Control of Quality of Manufactured Product* (New York: D. Van Nostrand, 1931).

13. Garvin, 3–5.

14. G. S. Radford, *The Control of Quality in Manufacturing* (New York: Ronald Press, 1922).

15. Quoted in Garvin, 5.

16. J. M. Juran and Frank M. Gryna, eds., *Juran's Quality Control Handbook*, 4th ed. (New York: McGraw-Hill, 1988), 242.

17. Garvin, 6.

18. William J. McCabe, "Examining Processes Improves Operations," *Quality Progress* 22 (July 1989): 26–32. McCabe makes a very strong point that simplification, through understanding the processes that exist in an operation, can save as much as one-quarter the cost of the entire process. We will cover this in more depth when we discuss continuous process improvement in chapter 2.

19. Feigenbaum, 275–99.

20. Ibid., 8.

21. J. M. Juran, ed., *Quality Control Handbook* (New York: McGraw-Hill, 1951), 24-8 through 24-15.

22. Juran, *Juran on Leadership*, 5.

23. For more information on the role of the military in the development of reliability, see Garvin; Juran, *Quality Control Handbook*; and Balbir S. Dhillon, *Systems Reliability, Maintainability, and Management* (Princeton, N.J.: Petrocelli Books, 1983). The first two authors disagree with Dhillon on when reliability became a recognized function of quality. Dhillon contends that reliability engineering actually started during the Second World War when the Germans were trying to increase the reliability of their V-1 and V-2 rockets.

24. Garvin, 15. A subsequent report by the Rand Corporation reported that for every vacuum tube in service, the military had nine to back it up.

25. Ibid.

26. Juran, *Quality Control Handbook*, 8-11 through 8-28.

27. Dhillon, 223–55. Dhillon's book captures the mathematical formulas and expressions necessary to fully understand and use availability.

28. Juran, *Quality Control Handbook*, 8-36, 8-37.

29. Garvin, 15. Garvin chooses to include reliability engineering under the major area of quality assurance, as opposed to Juran, who sees two distinct specialties—quality engineering and reliability engineering.

30. Juran, *Quality Control Handbook*, 5-1, 5-2.

31. Y. K. Shetty, "Managing Product Quality for Profitability," *SAM Advanced Management Journal* 53 (Autumn 1988): 33–38.

32. Feigenbaum, 77–108.

33. Ibid., 6.

34. Ibid., 78.

35. Theodore W. J. Wong, "Search for Fault-Free Production," *National Defense* 23 (February 1989): 48–51.

36. Feigenbaum, 823–29.

37. Ibid., 94.

38. Ibid., 109–45.

39. Ibid., 14.

40. Shetty, 33–38.

41. Halpin, 3.

42. Ibid.

43. Ibid., 16–17.

44. Ibid., 54–55.

45. For a full explanation of strategic quality management, see Garvin, chapter 2. Strategic quality management and DOD's total quality management program are similar.

46. John R. Hauser and Don Clausing, "The House of Quality," *Harvard Business Review* 66, no. 3 (May–June 1988): 63–73.

47. Fikra II. Boghossian, "Build Quality In; Don't Inspect It," *SAM Advanced Management Journal* 53 (Autumn 1988): 44–47.

48. Philip B. Crosby, *Quality Is Free: The Art of Making Quality Certain* (New York: McGraw-Hill Book Co., 1979), 14–17.

49. W. Edwards Deming, *Out of the Crisis* (Cambridge, Mass.: Massachusetts Institute of Technology Center for Advanced Engineering Study, 1986).

50. Garvin, 38.

51. William F. Roth, Jr., "The Great Shell Game," *Personnel*, December 1988, 53–58.

52. John D. Rittenhouse, "Raising the Quality Standard in Defense Manufacturing," *Defense Management Journal* 22 (January–March 1986): 12–17.

Chapter 2

Total Quality Management

Quality is never an accident; it is always the result of high intention, sincere effort, intelligent direction and skillful execution; it represents the wise choice of many alternatives.

—Willa A. Foster

Total quality management is defined in the 4 May 1989 Office of Assistant Secretary of Defense for Production and Logistics (OASD P&L) TQM-IPQ Fact Sheet:

> Total Quality Management (TQM) is both a philosophy and a set of guiding principles that represent the foundation of a continuously improving organization. TQM is the application of quantitative methods and human resources to improve the material and services supplied to an organization, all the processes within an organization, and the degree to which the needs of the customers are met, now and in the future.[1]

Compare it with Feigenbaum's definition of total quality control in 1951:

> An effective system for integrating the quality-development, quality-maintenance, and quality-improvement efforts of various groups in an organization so as to enable marketing, engineering, production, and service at the most economical levels which allow for full customer satisfaction.[2]

The difference is in the establishment of a foundation for continuous improvement. This antithesis of the famous American saying, "If it ain't broke don't fix it," is what makes TQM the next revolution in American business and in DOD. TQM expands on the work of Dr W. Edwards Deming, Dr J. M. Juran, and A. V. Feigenbaum, and it is applicable to both government and nongovernment organizations.[3]

For TQM, *quality* is defined as "providing the customer what he or she expects to receive."[4] One must therefore be able to define and understand the customer's desires, expectations, and preconceived notions. No customer expectation is too strenuous, too extreme, or too outrageous. Within this framework, anything is possible.

Quality expectations are achieved through a focus on five elements: people, equipment, materials, methods, and environment.[5] Each element is focused on the business operation and is organized to meet customer expectations through a process of continuous improvement. The product can be either internal or external. *External* is how we think of products for customers—external to the company. *Internal* recognizes that some products or services are for internal use only. These internal products may be combined with others to form a product for external consumption, or

they may be for internal consumption exclusively, like paychecks or quality inspections. These products, whether internal or external, will have robust designs and, when measured against standards, will be grouped close to the mean.[6]

Key Concepts

TQM is an all-encompassing concept that combines technical aspects of quality, qualitative methods, and human resources in a system designed to provide the very best product. Processes and techniques are integrated within a system that is focused on continuous improvement through highly trained and motivated system members.[7]

TQM principles serve as the foundation for managers and other system members to use in analyzing decisions and future planning actions. They provide a framework to assess outcomes and appraise behavior. TQM's nine principles guide the work done by each member of the system—and they force accountability on management.

Principles

1. Continuous Process Improvement. This is the prime principle. It permeates the entire TQM system and is implemented through a systematic and disciplined process.

2. Process Knowledge. Knowledge of the process is necessary for continuous improvement. It requires a thorough understanding of each process in the system, and it promotes improvement ideas.

3. User Focus. User focus is both internal and external. All products and services in an organization have an internal or external user; but more important, to meet the needs of the external customer, internal customers must be satisfied by receiving products or services that meet conformance requirements.

4. Commitment. In order for TQM to work, it must have commitment from all members of the system. Most important is the total commitment of top management. TQM success is directly related to system workers' beliefs that management is committed to a continuous improvement program that reduces cost and ensures schedule compliance, customer satisfaction, and pride in individual workmanship.

5. Top-Down Implementation. Just as a teacher must learn a new subject before teaching it to students, managers must learn TQM as a new management philosophy before they can expect system workers to understand TQM and use it. The difference between TQM and other management approaches is that system workers are active participants in the process.

6. Constancy of Purpose. TQM starts with a vision established by senior leaders and is implemented through a series of goals and objectives. Everyone's activities in the system are focused on the objectives and goals. Recognition is given to those who maintain the focus of continuous improve-

ment. Rewards are given for positive behavior. Negative behavior, which accepts accommodation to a status quo environment, must be repaired.

7. Total Involvement. No individual or process is exempt from continuous improvement. This requires that processes meet conformity requirements and that individuals be fully trained and knowledgeable of TQM techniques for continuous improvement. Less than total involvement is like "acceptable quality level"—acknowledgment that some part of the system will fail, and that it is okay.

8. Teamwork. Teamwork leads to efficient application of resources, correct processes, and great results. Teams support system goals through hands-on ownership of (responsibility for) objectives that support the overall system. Teams foster improved communications, creativity, and support of the TQM principles.

9. Investment in People. The system's greatest asset, and most significant investment, is its people. Continuous improvement requires that people improve also. TQM is committed to training and education for system m~mbers.[8]

Management Involvement

An important fundamental of TQM is that managers at the uppermost levels of the organization must initiate a quality revolution. TQM will succeed only with the constant commitment of senior leaders. John A. Betti, vice president and member of the board of directors of Ford Motor Company and chairman of the board of Ford Aerospace, relates an interesting story on how Ford got the inspiration:

> In 1980, some of our people saw the NBC documentary, "If Japan Can, Why Can't We?" [in which] great tribute was paid to Dr. Deming. Someone suggested we invite him to teach us what he taught the Japanese. But Dr. Deming wasn't interested in visiting us until we convinced him we were really focused on quality and would do what was necessary to achieve important improvement. He came in January, 1981. He was much younger then, only 80. I distinctly remember some of his first visits. We wanted to talk to him about quality. He wanted to talk to us about management. We wanted to know what quality improvement tools we could use. He wanted to talk about cultural change. We wanted to know what programs would work. He wanted to discuss senior management's vision for the Company. It took time for us to understand the profound cultural transformation he was proposing. Proposing is actually too weak a word to describe his message. He viewed cultural change as a matter of life or death for American firms: not just Ford, but any enterprise. It would require a common sense of purpose and direction. And it had to start at the top. Dr. Deming's questions and guidance helped us start the process of assessing what kind of company we were and what we wanted to be.[9]

The function of management is to ensure that organization activities are carried out as planned.[10] If top management is totally committed to a cultural change and if that commitment is transmitted throughout, then the organization can achieve its goals. Without top managers' involvement in TQM, the cultural change will be like most other programs—it will come to an end. This idea was expressed by James Harrington when he said,

"The improvement process starts with top management, progresses at a rate proportional to their demonstrated commitment, and will stop soon after they lose interest in the process."[11]

Continuous Improvement

The hallmark of the TQM process is the concept of continuous improvement, which relies on systems and processes that *build* quality into a product, not *inspect* it in.[12] Continuous improvement requires that improvements occur *beyond* an "acceptable" quality level; it puts quality first, before cost and schedule. Continuous improvement never ends.[13]

Management must be of such quality that, throughout the organization, managers find ways to inspire, motivate, and educate employees in the continuous improvement process. Goals, tools, rewards, and training must be used properly. Training should focus on the system or process, on statistical process-control techniques for all employees, and—in the case of management—on skills that will empower employees to improve processes. TQM is a management system that replaces previous systems such as status quo or quarterly financial management.[14]

The quality of all processes at all levels must be assured at all times. Managers must seek out areas that are out of control, develop measurement indicators, and systematically replace inertia with continuous, planned improvement. Each and every process must be defined, measured, and analyzed; and corrective action must be taken where needed. *Ownership* for each process must be established.

TQM focuses the efforts of the entire operation on customer satisfaction. Management must establish an atmosphere that encourages satisfaction of internal customers as a means of better meeting the expectations of external customers. Management must establish a framework for fully understanding customer requirements (expectations) and convert them into a set of fully understood conformance standards that are measurable and attainable.

TQM relies heavily on functional teams. The TQM organization is made up of process teams that are a part of larger functional teams which are a part of end-product teams. All teams and individuals understand their jobs and their customers' expectations. This understanding comes about through participation in process identification, measurement, evaluation, and correction.

TQM requires the total commitment of top management. Top managers demonstrate this commitment through the use of TQM as their management philosophy. They establish time-phased goals (long, medium, and short) and measure the organization's progress toward these goals. They establish a decision-making process that emphasizes quality and the customer, not short-term gains. Promotions and rewards within the organization are given to those whose actions are consistent with the TQM philosophy. This demonstrates management's long-term commitment and

also ensures that the TQM philosophy is carried into the next generation of the organization's leadership.

Total quality management relies on statistical process control to determine where any problems are, to evaluate cause-and-effect relationships, and to assist in a systematic decision-making process designed to solve these problems. TQM requires more training than other systems because it is an unending process. The organization is always engaged in training and education. Training starts with all employees being taught how to employ statistical process control (SPC) and process flow techniques and how to develop visual representations of problems with quality. As training continues, SPC understanding is further refined and specialized processes are taught. Managers receive training in techniques to obtain employee participation in the TQM process.

The TQM system cannot be established overnight. It takes a long time to fully implement it, and it should be developed in a time-phased approach designed to keep the attention and interest of both managers and employees.

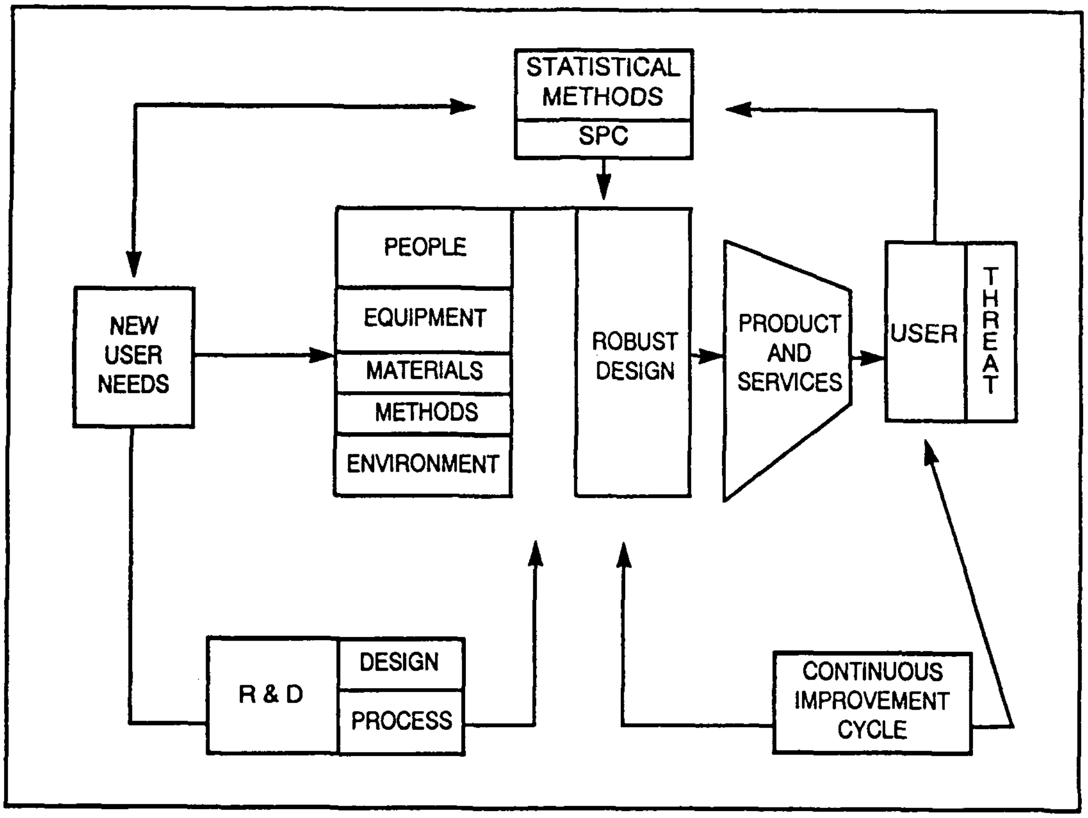
Production Viewed as a System

Total quality management must be viewed as a total system concept that encompasses "the full scope of the product or service 'life cycle' from product conception through production and customer service."[15] "The Japanese Industrial Standard (Z8101-1981) defines quality as *a system of means* [emphasis added] to economically produce goods or services which satisfy customers' requirements."[16] Total quality management affects the entire industrial cycle: marketing, engineering, purchasing, manufacturing engineering, manufacturing supervision, shop operations, mechanical inspection, functional test, shipping, installation, and service.[17] Other activities such as research and development, prototype building and testing development drawings, and personnel management are also directly touched by TQM. Total quality management is a closed-loop system (fig. 3).[18]

Cost of Quality

There are two distinctive views of quality. The first is represented by the classic American school, the second by some progressive American schools and the Japanese school. The classic "production base" approach believes that increased quality means increased production cost, increased production time, and an expanded inspection system to ensure quality.[19]

The second approach views quality and cost as inversely related. It believes that the cost of providing a quality product or service is less than the cost of scrap, rework, and repair. This second approach, which encompasses the "continuous improvement" concept and an absence of defects throughout the production system, is the focus of TQM.[20]



Source: Thomas R. Stuelpnagel, "Total Quality Management," *National Defense* 72 (November 1988): 57–62.

Figure 3. TQM as a System

TQM asks, What are the costs of quality? and then asks how to reduce them. Table 4 represents some quality cost areas but is not all-inclusive—costs can and do change.

Table 4

Quality Cost Components

- Cost of incoming inspection
- Cost of carrying more inventory than needed for efficient operations
- Cost of carrying lowest cost subcontractors
- Cost of imposing outdated specifications and quality standards
- Cost of material scrap
- Cost of rework
- Cost of repair
- Cost of machine downtime
- Cost of learning curve inefficiencies
- Cost of disposition of unusable parts
- Cost of field service operations
- Cost of material/cost adjustments
- Cost of returned material
- Cost of multiple shipments

Table 4—*Continued*

- Cost of warranty
- Cost of test equipment and calibration
- Cost of planning quality
- Cost of training
- Cost of process control
- Cost of running quality data system
- Cost of improvement programs like zero defects or TQM

Source: J. M. Juran, *Quality Control Handbook* (New York: McGraw-Hill, 1951), 5-4, 5-5, 5-6.

When and where a quality failure is detected is also important. A 100,000 percent increase in cost can occur if a component fails in the field as opposed to during inspection. Further, according to General Electric, error costs increase by an order of magnitude as components move through the industrial process.

> The earlier you detect and prevent a defect the more you can save. If you can catch a two cent resistor before you use it and throw it away, you lose two cents. If you don't find it until it has been soldered into a computer component, it may cost $10 to repair. If you don't catch the component until it is in the computer user's hands, the repair will cost hundreds of dollars. Indeed, if a $5,000 computer has to be repaired in the field, the expenses may exceed the manufacturing cost.[21]

As companies begin to understand quality costs and processes that go into quality, cost of quality goes down and productivity goes up.[22] As increased attention is paid to quality, productivity and customer satisfaction are increased. Total quality management must be viewed as a strategy employed to achieve success rather than a function that must be satisfied.[23]

In a study of the differences in quality between US and Japanese air conditioners, David Garvin concluded that "failure rates from the highest-quality producers were between 500 and 1000 times less than those of products from the lowest."[24] And Norman Augustine concluded that as more "quality is built into a product, the cost of achieving quality does not increase but rather decreases. This led to Augustine's Law 12: 'It costs a lot to build bad products'."[25]

Quality and Productivity

Quality and productivity are components of cost in any operation. However, productivity is viewed differently because management generally has held that productivity is an indicator of organizational health.[26] One reason is that it has been easier to measure productivity. Yet, it is not a good measure because it has historically included all products, even those that fail. Management needs to understand the relationship between quality and productivity and the components of each.

When productivity and quality are seen as interrelating and functioning within the same closed system, any increase in defect-free output will

increase both quality and productivity.[27] Seeing the interrelationship between productivity and quality will give management a truer measure of organizational behavior and customer satisfaction. Improvements in productivity can include standardized parts, modular designs, simplified assembly, fewer engineering changes, fewer process errors, and less excess capability waiting for rework.[28] Quality and productivity share the same roots (fig. 4).

$$\text{PRODUCTIVITY} = \frac{\text{INPUT}}{\text{TOTAL OUTPUT}}$$

$$\text{QUALITY} = \frac{\text{DEFECT-FREE OUTPUT}}{\text{TOTAL OUTPUT}}$$

Figure 4. Quality and Productivity

Management of Outcomes versus Management of Processes

The typical management approach reacts to events that occur in the system; the TQM approach continuously works on the system. The first approach corrects problems topically, without understanding the systemic causes. In many cases the topical correction causes other problems. The latter approach understands what the system is and how it functions. It determines the cause of a problem, then corrects it. TQM formalizes the process and makes it routine. The formalization occurs in seven major areas.

1. Planning and Goal Setting. Planning through goal setting attempts to forecast the future. It sets the organizational course. Effective planning forces the system to review customer requirements concerning people, equipment, methods, materials, and the environment. A good planning system is institutionalized. It forces managers to plan activities that support organizational goals through teams that support higher-level and broader goals (fig. 5). At the very top of the organization, a vision is established to provide a purpose and a clear direction for the organization. From this vision, goals that support the vision are developed. At the next level, objectives that support the goals and are consistent with the organization's vision are developed. The planning system must ensure that

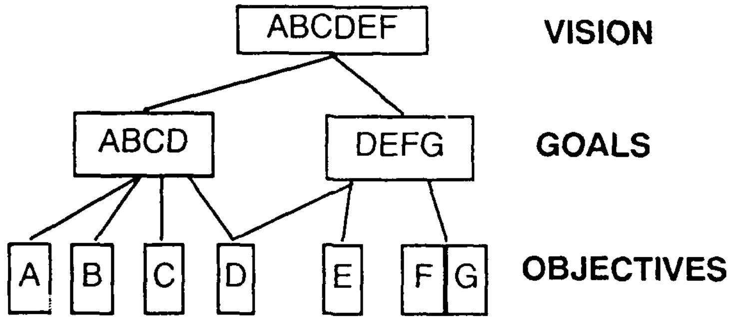


Figure 5. Vision, Goals, and Objectives

the goals and objectives are consistent with the vision. Throughout this process, quality improvement remains the nucleus of all activity.

2. Promoting Improvement. The best way to promote an improvement program is to live and breathe it every day. Quality and improvement should be the first things system workers think of before they take any action and the last things they think about when they evaluate the corrective action. Philip Crosby offers a 14-step program for quality improvement from the perspective of the quality leader who is charged with initiating it.

> Step 1. *Management Commitment*. Get the attention of managers by emphasizing defect prevention. Explain what the cost of quality really is and what poor quality could take from the bottom line (profit). Prepare a quality policy statement that clearly specifies what is expected of individuals in the organization. Explain to the top managers why they must be committed for the long run and why they must provide visible support.
>
> Step 2. Quality Improvement Team. Have management establish a quality improvement team made up of department leaders or someone who can speak for the departments. Explain the purpose of the program—quality awareness—to the team members. Explain that their role is to generate the ideas needed to carry the program forward.
>
> Step 3. Quality Measurement. Measure everything in the company. Manufacturing firms traditionally establish quality measurements, and these may be sufficient if they address all aspects of quality. But

Crosby makes specific recommendations for other measurements so that improvement can be demonstrated. Many of these measurements are in the so-called soft area—administration.

Accounting
- Percent of late reports
- Incorrect computer input
- Errors in specific reports

Data Processing
- Keypunch cards [data input] thrown out for error
- Computer downtime due to error
- Run time

Engineering
- Change orders due to error
- Drafting errors found by checkers
- Late releases

Finance
- Billing errors
- Draft errors found by checkers
- Accounts payable deductions missing

Manufacturing Engineering
- Process change notice due to error
- Tool rework to correct design

Marketing
- Contract errors
- Order description errors

Plant Engineering
- Time lost due to errors
- Callbacks on repairs

Purchasing
- Purchase order change due to error
- Late receipt of order
- Rejections due to incomplete descriptions

Start with a flow diagram of each function and then measure each output. At decision points, record the time it takes to make the decisions. Get everyone involved in the process and display the different measurement areas around the company. Don't hide the ones that are not up to the standard—pride is a powerful incentive for movement.

Step 4. Cost of Quality Evaluation. The cost of quality must be measured. This measurement should be done by the comptroller to reduce perceived bias. The cost can be refined as time goes on and everyone becomes more educated in quality. The important thing is that the company now has a measure of the cost of quality.

Step 5. Quality Awareness. This is the most important step. It makes all employees aware of what the poor quality has been costing the organization. All employees contribute to product quality. Quality awareness activities should focus on helping employees understand how to talk about quality, how to look for problems needing corrective action, and how to correct errors.

Step 6. Corrective Action. Employees have now learned the cost of poor quality and the areas being measured. They will begin to identify problems and seek means to correct them. They should begin to make suggestions on how to improve. These suggestions should be reviewed and acted on in supervisory meetings at each level. Functional managers are responsible for correcting problems in their areas. When employees perceive management taking action, they are more willing to participate in the quality program.

Step 7. Ad Hoc Committee for the Zero Defects Program. Three or four members of the quality improvement team should be selected to determine how a quality improvement program can be initiated in the organization. The quality program is not a motivational program, but a program to help employees do things right the first time, every time. The quality program is installed after the quality awareness program has been under way for some time. The measurements that have been taken so far should show significant progress. The perfect time to initiate the quality program is when the rate of progress reaches a plateau.

Step 8. Employee Training. This is a critical point in the transition. All employees must be adequately trained. Job training should include statistical process-control techniques, process measurement, and communication skills in the workplace.

Step 9. Zero Defects Day. There must be a point of demarcation between the old system and the new one. The old way was to accept a "level" of poor quality; the new way is to put all the efforts of the organization toward defect-free products and services. A zero defects day, by whatever name, is that point of reference. Everyone in the organization will remember the day that a major cultural change occurred.

Step 10. Goal Setting. Regular meetings on quality should be focused on goals. Employees need to establish short-, medium-, and long-term (30, 60, and 90 days, respectively) goals. This process encourages employees to make progress in small chunks over manageable periods of time. More important, if the employees establish the goals, they feel some ownership, which increases the probability of success. This process should especially be used with teams to support their work in the organization.

Step 11. Error Correction. Error correction underscores the importance of the customer and of making sure that each process is correct. When problems and/or errors are found, they are documented on a company-generated form and passed on to the team or person that can best answer why the problem exists, how it can be corrected, and when. Answers should be generated and returned within 24 hours, and no group should be exempt from providing an answer—upper management in particular. If upper management fails to answer a question, employees will quickly recognize that the quality program is really a one-way program.

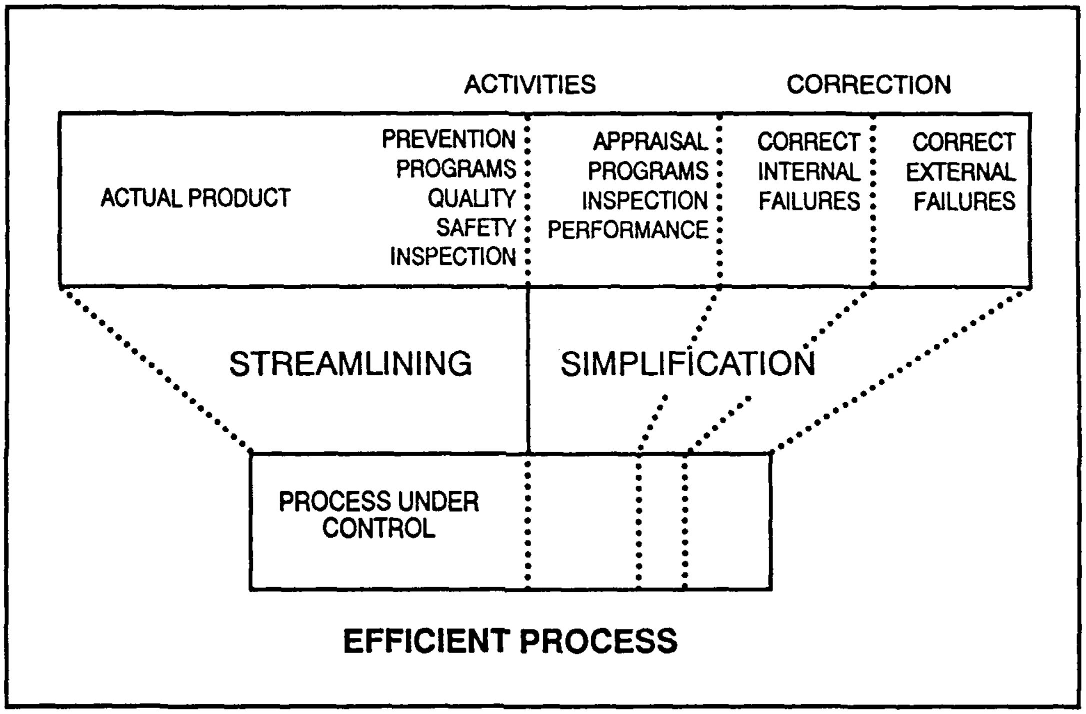
Step 12. Recognition. Recognition programs should be established to reward individuals and groups for meeting their goals. Error correction proposals should be treated the same as proposals for meeting goals since both achieve the same purpose. Recognition should be given as quickly as possible, and it must be meaningful.

Step 13. Quality Councils. The quality improvement team should meet on a regular basis. Everyone should keep communicating on improvements, goals, and problem solving.

Step 14. Do It Over Again. The process must become routine—a way of life, like breathing. Employees must know how to do their jobs, and the infrastructure of the system must accept only error-free products and performance. The process must be revived constantly. New people must be trained, and exceptional performance must be rewarded with promotions. No one unsupportive of the quality program should ever be promoted, regardless of the reason, over a total quality employee. *Upper management must stay engaged.*[29]

3. Process Improvement. Process improvement breaks down all the organization's processes into well-defined activities. Each should have a starting point, and should conclude when the product is either delivered or assimilated into another process. Statistical process control is employed on all process activities. TQM requires a statistical approach to thinking—that is, looking at all the data and determining whether the products are within standards. Statistical process control is a good way of doing this. It should be used throughout the company to get everyone thinking the same way. After this thinking becomes the norm, the volume of statistical process control will decrease, but the approach will not change.[30] In addition to statistical process control, other techniques such as process streamlining (fig. 6) and improvement cycle (fig. 7) are used to improve the efficiency of each process. These analysis techniques assure accurate investigation of process objectives, requirements, and capabilities.

4. Signals. Management signals are attended to by system workers. Any slackening of senior management commitment will cause shock waves throughout the organization, and TQM will die a sure death. The organization's educational apparatus must foster TQM in entry-level and core-system courses for all employees before any specialized education is



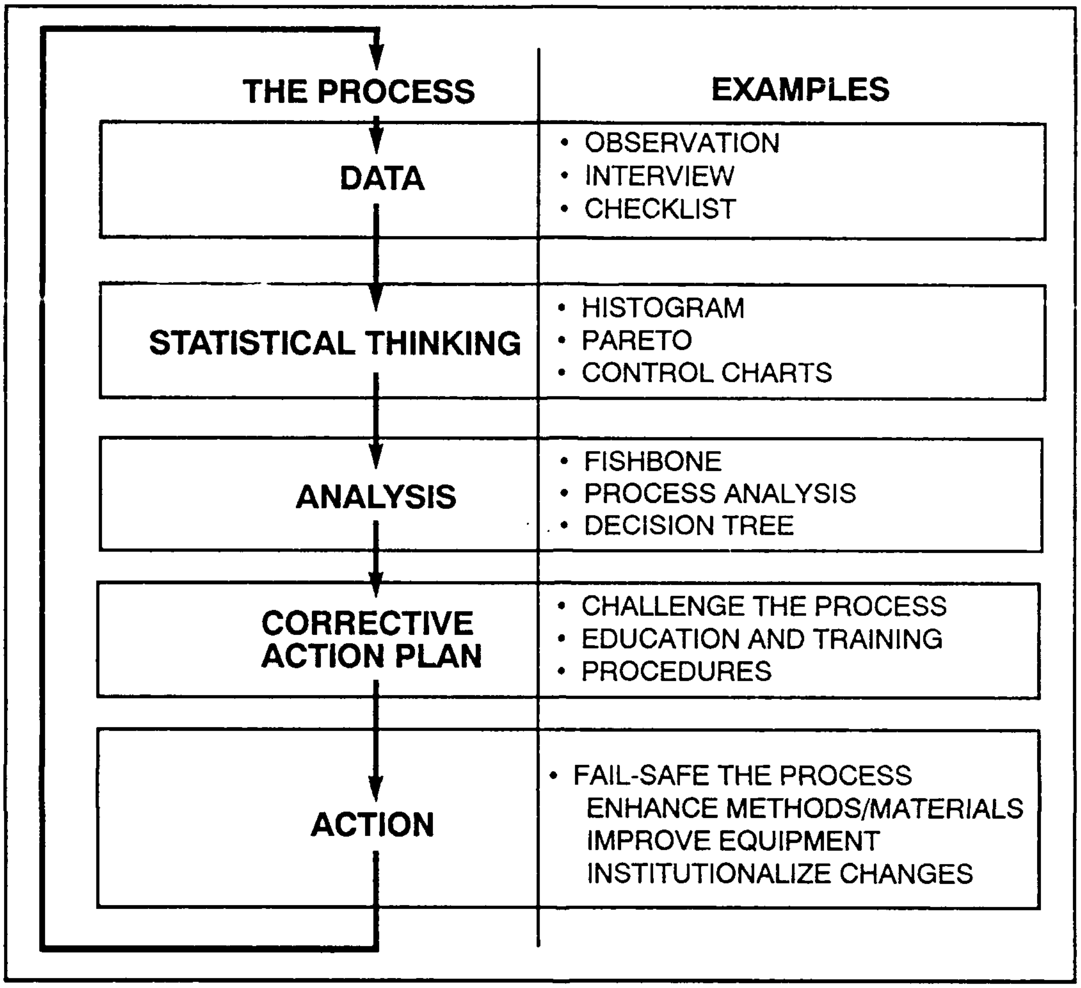
Source: William J. McCabe, "Examining Processes Improves Operations," *Quality Progress* 22 (July 1989): 26.

Figure 6. Process Streamlining

provided. Those TQM advocates and system workers who exemplify the TQM philosophy should be promoted into senior positions to ensure continued success. Promotion of anyone else would signal that TQM is not the only acceptable management approach. Both process and individual must continuously receive the right signals.

5. Communication. Constructive and uninhibited communication up and down the organization is critical to the success of TQM. One of the first processes reviewed is that of communication within the organization. Any roadblocks or processes that prevent communication, such as initial hesitation in the application of TQM by a midlevel supervisor, should be eliminated. Communication systems and interpersonal lines of communication should recognize this hesitancy and work to get the information through the midlevel supervisors. One effective tool is the organizational team. The use of organizational teams will force the midlevel supervisor to feel some ownership of processes and improvements.

6. Skills Building. TQM is not free, but investment in it will return great rewards. The predominant cost of TQM is in training and skills building. But training costs occur no matter what type of management philosophy one uses. One of the first things cut in the short-term management philosophy, training is the first item funded and the last to depart in TQM.



Source: DOD 5000.51-G, "Total Quality Management Guide," final draft, vol. 1, 23 August 1989, 9.

Figure 7. Improvement Cycle

Skills are developed in group dynamics, quantitative measurement techniques, and process-improvement procedures. It is only through training that each individual will know the job.

7. Resource Optimization. Part of the payback in TQM is that processes and resources are less costly to operate and maintain than in a traditional organization. TQM frees individuals to look at each process and determine the optimum amount of resources at just the right time. As processes are refined and subcontractors and vendors are selected on the basis of continuous improvement—not lowest cost—TQM will more than pay for itself. Processes like just-in-time (JIT) inventory control, process streamlining, and value-added analysis will keep the system operating efficiently and make optimal use of all the organization's resources.[31]

Deming, Juran, Feigenbaum, and Crosby appreciated the need to go beyond the quality inspection charts and incorporate the essentials of human dynamics, organizational development, and motivational theory in TQM. The key concept is that management must take responsibility for the system.

The Fourteen Obligations of Top Management

The goal of TQM is quality. One aspect of ensuring quality is the elimination of obstacles that hinder quality improvement, many of which were established by management. To underscore the importance of the change needed in management, Dr Deming developed 14 obligations of top management.[32] They are the basic elements that were taught to the Japanese in the early 1950s. Dr Deming felt that some companies were being carried away with statistical methods to the detriment of the other principles.[33] Statistical methods should be used early in the implementation of TQM to get everyone on the same level. Their significance then diminishes. The 14 obligations of top management are as follows:[34]

1. Create constancy of purpose toward improvement of product and service, with the aim of becoming competitive and staying in business and providing jobs. Management must do everything possible to eliminate the quarterly profit-and-loss mentality, which is one of the biggest detriments to long-term growth in our country. Managers and leaders must establish a structure that will be around for the long run. The practice of moving managers and leaders frequently must be stopped; frequent movement causes them to come to jobs with a short-term attitude and to leave with the same attitude. Promotions should be based on all their past positions in the organization, not just the last one. The continuous improvement process should also include better methods of production, better application of materials, revitalized training, retraining, continuous updating of training aids, and training funds for the future. Part of today's funds must go toward research and development to improve products, maintenance, and service; without an understanding of the customer's future requirements, an organization will not be prepared.

2. Adopt a new philosophy in a new economic age. Western managers must awaken to the challenge, learn their responsibilities, and take on the leadership for change. This goal will be achieved only if the organization demands high quality, dependable products, and reliable services. Too often, shortsighted managers allow lower quality and undependable products. Some managers actually plan for low quality, less dependable products, defects, workers who don't know their job, poor training, worse supervision, slipped schedules, and cost overruns. Managers who plan for poor quality get poor quality.

3. Cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place. *Build* quality in—don't *inspect* it in. The best way to build

quality into the product is through robust design and the elimination of variability. To understand variability, one must use statistical process-control techniques. Statistical design has not been used much in the United States, but industries that use it extensively dominate the world market.[35] Statistical process control utilizes such tools as flowcharts, Pareto diagrams, cause-and-effect diagrams, run charts, scattergrams, and histograms. Workers who know how to apply statistical process-control techniques are better able to find the problems an inspector would find. When the system worker finds problems and corrects them, it is looked at as part of the job; when an inspector finds errors, it is considered a failure. And blame is generally assigned to the system worker, not management. As quality improves, inspection should decrease. Lack of inspections can even be used as a reward for units that are producing quality products and/or services. In addition to eliminating the reliance on mass inspection, replacing military quality standards with a statistical process-control system geared to continuous improvement would go a long way toward recognizing producers of quality.

4. End the practice of awarding business on the basis of the price tag. Instead, minimize total cost. Move toward a single supplier for any one item, building a long-term relationship of loyalty and trust. Dr Deming's feelings on this subject are presented below. He is referring to the purchase of municipal buses from the lowest bidder.

> To have somebody that knows something about quality, they'd have to pay money. Such people are high priced. But they would save untold sums of money. It requires only a third-grade dropout to observe which price is the lowest, and he's the one that gets the job.
>
> There's a better way today. We're in a new economic age, which requires that suppliers give statistical evidence of quality in the form of control charts and evidence that they are working on all 14 points. Quality and competition are not directly related when the goal is the low-bidder. All bidders for a product or service should be required to prove that they employ statistical process control and that the products they are offering are in statistical control. When this happens bidders will be forced to look for the best with the lowest cost of ownership, not the lowest initial price with the highest ownership cost. Additionally, this will force bidders to develop long-term relationships with their suppliers who are in statistical control and able to provide quality parts, not low-priced parts. In the long term, high-quality parts in statistical control will be low-cost parts.[36]

5. Constantly improve production and service systems to improve quality and productivity and thus constantly decrease cost. Don't wait for things to go wrong. Put the entire work force in a posture to find problems before the system goes out of control. Plan for a system that is forever in control, forever getting better. Retrain quality inspectors to become teachers of statistical control and advanced experiment facilitators. Make them a part of each work unit.

6. Institute training on the job. An employer cannot expect to hire fully trained employees. Company training is therefore mandatory. Training is a continuous process that matches the needs of the worker to the require-

ments of the system. Both benefit through increased satisfaction and productivity. Statistical methods should be used to determine what training is needed, when it is needed, and when it is complete. As training becomes effective, product quality improves. In those rare cases where the proper training has not improved the output of a unit or individual, that unit or individual should be relocated or discharged.

7. Institute leadership (see point 12). The aim of leadership should be to help people and machines do a better job. Too little attention is given to training supervisors and ensuring that they are managing with statistical control. Management must teach supervisors what their jobs are and allow them to ask questions. The supervisor should serve as a coach, helping system workers solve problems. Foremen and midlevel supervisors are essential to quality education, and top leaders must recognize that continuous improvement is the means to achieve customer satisfaction. The leaders of organizations must find ways to reduce the amount of time that foremen and supervisors spend on nonproductive work. Some activities and situations that are commonly found in organizations and that might be classified as nonproductive are listed below.

- Weekly sign off of time cards verifying attendance
- Inspection of incoming parts between divisions
- Unnecessary personnel in approval cycle of manager's travel request
- Work-measurement system
- More quality standards
- An acceptable quality level
- Ineffective communications systems
- Travel when teleconference would suffice

8. Drive out fear so that everyone may work effectively. Dr Deming estimates that probably 80 percent of American workers do not know and are afraid to ask what their jobs are.

> And why is the American worker afraid? Well, somebody trained him, maybe the foreman. But he still doesn't understand what to do. Or there is some material that is unsuited to the purpose. He asks for help two or three times, but the foreman never has any time or tells him, "Well, it's the way I told you." So the worker doesn't wish to be a trouble maker. He works in fear.[37]

Just as top managers are responsible for other components of the system, so are they responsible for supervision. Supervision that instills fear and fosters ignorance is intolerable. Like other parts of the system, supervision must be continuously improved. Supervisors must be trained in statistical process-control techniques so they can identify quality costs and help workers eliminate barriers to quality. Supervisors must not be afraid to ask questions, flag problem areas, and make suggestions.

9. Break down barriers between departments. People in research, design, sales, and production must work as a team. The time has come to break down the walls that nurture divisions within the system. These walls prevent cooperative work between and across divisions. The lack of cross-

functional assignments has contributed to worker ignorance of the total organization. This must change! Everyone must contribute to the system's goals. Multifunctional teams with common goals and objectives should be the goal of every senior executive officer, divisional manager, supervisor, foreman, and worker.

10. Eliminate slogans, exhortations, and targets for the work force. If the company president wouldn't hang the poster in his office, it doesn't belong on the shop floor. Posters should reflect company goals, the status of the work being done, and the work that is not yet under statistical control but is getting there. Give the workers a map of where they have been, where they are, and where they are going. (A slogan like Zero Defects tells them what is expected but not how to get there.) "The slogan advertises to the work force that management is helpless to solve the problems of the company. Do they need to advertise? The workers already know it."[38]

11a. Replace work standards (quotas) on the factory floor with leadership. Work standards have a way of limiting improvement because the workers know that their every movement is measured and gauged. The best form of work measurement in a production operation is statistical process control. Once a process is in control and the efficiencies found, no work-measurement system will improve the process. Quotas emphasize quantity over quality, leading eventually to higher cost.

11b. Eliminate management by objective. Eliminate management by numbers. Substitute leadership. Management by objectives is the misapplication of a good concept. Objectives are established by management and forced to lower levels where lower-level objectives must be created to support the higher-level ones. This imposes a requirement on system workers without giving them a means to satisfy it. Further, the documentation required—and cheating that occurs in reporting the progress—is counterproductive. Managing through the use of vision, goals, and objectives can be effective, however, if two conditions are met: objectives should originate at the lowest levels of the organization after a clear understanding of the organization's vision is in place, and the documentation should be the same as that used to measure and maintain process control.

12a. Remove barriers that rob hourly workers of their right to pride of workmanship. The responsibility of supervisors must be changed from numbers to quality. Satisfied system workers do not set out to produce bad products or provide poor service. If they do a poor job, it is because the system failed to ensure that they stayed within the desired control. To ensure that they know when a worker is about to fall out of control, managers must establish communication lines through which information can freely pass. These lines of communication are critical; through them come warnings of approaching dangers. Teamwork requires communication and inspires pride in daily work.

If every team of 10 members were able to bring one individual's behavior closer to the group's mean, the entire system would be improved. In any group, someone has to be in the top percentage and someone has to be in the bottom percentage—we can't change the laws of distribution. But we can reduce the variability between the top 10 percent and the bottom 10 percent, and we can increase the pride possessed by the lower 10 percent.

12b. Abolish the annual or merit rating. TQM offers a replacement for annual ratings: statistical process control and teamwork. Bill Scherkembach, Ford's director of statistical methods, said the performance system "destroys teamwork and cooperation, fosters mediocrity, increases variability, and focuses on the short term. In addition, it treats people like commodities and promotes fear and loss of self worth."[39] But an annual performance system can work if the areas of measurement are changed to teamwork, long-term goals, and continuous process improvement. Too often, annual appraisals are based on outcomes not under the control of the individual but of the system. Only about 15 percent of a company's processes are under the control of workers; the other 85 percent are under the control of management.[40] Myron Tribus addressed the issue of manager selection in a presentation to the Society of Automotive Engineers in early 1983:

> Managers will not "parachute" into their positions from outside. They will be developed, over time, from within their companies through rotation around different parts of their organizations. Then the selection of top management can be made from among people who understand a company and know what it means to improve the quality of the output of the systems. This means harmonizing activities related to improving 1) the quality of the input—information, materials, delivery, storage; 2) the design and operation of the system, including the relation between the different departments; 3) the on-the-job training of all employees; and 4) implementation of quality enhancement through feedback.[41]

Appraisal systems will work if they are fairly applied, are consistent with the goals and objectives of the organization, and provide information the worker can use for continuous self-improvement.

13. Institute a vigorous program of education and self-improvement. TQM is effective when everyone in the organization is trained in basic statistical process methods. They must understand these methods and use them to solve problems. Because the entire organization is trained in statistical process control, it frames the way the organization looks at problems and corrects quality deficiencies. Training must accomplish three objectives: (1) it must make all system workers aware of the benefits of the TQM approach; (2) it must educate all workers on the use and application of statistical tools used in TQM; (3) it must relate the TQM process to the jobs and functions that will be under their control.[42] If the training is successful, the workers will have the tools to monitor and correct quality deficiencies and to progress toward a continuous improvement system.

They will have the rewards and satisfaction of seeing the new process work on a system under their control, and they will have the motivation to continuously improve.

14. Put everyone in the company to work on the transformation. Just as important as putting in a system for continuous improvement is the requirement that everyone in the system be involved in making it better. If there is one thing different between TQM and any other management program, it is that TQM is for everyone.

Variation: A Cause for Quality Lost

Another way of understanding quality is through established requirements or standards. Neither products nor services are absolutely perfect; they vary around "target" tolerances. These tolerances are referred to as an upper control limit (UCL) and a lower control limit (LCL). Both the UCL and the LCL are expressions of variances from a target value. For example, in the production of a widget, the design engineer specifies that its weight shall be 10 pounds, plus or minus 1 pound. The target is 10 pounds, with the UCL at 11 pounds and the LCL at 9 pounds (fig. 8). Anything that falls between the two "goalposts" is acceptable. The problem with this approach is that variance or variability can occur within the standard (fig. 9). This variability causes a loss of quality through "standards stacking"—not to mention increased material cost and shipping cost.

The opposite approach is "loss function," the creation of Genichi Taguchi. The focus of the manufacturing effort is on the target value—not just anywhere between the goalposts. Close conformity is achieved by reducing variability in the production processes. Taguchi even goes so far as to accept that some of the items that fall beyond the goalposts are acceptable as long as the vast majority fall close to the target.[43]

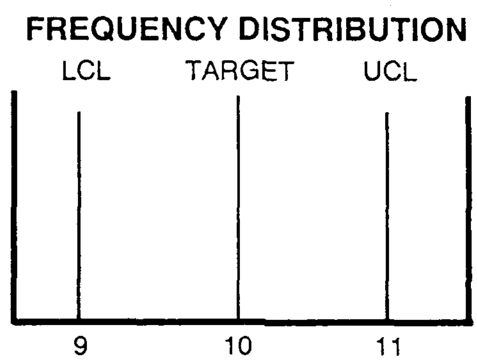


Figure 8. Upper and Lower Control Limits

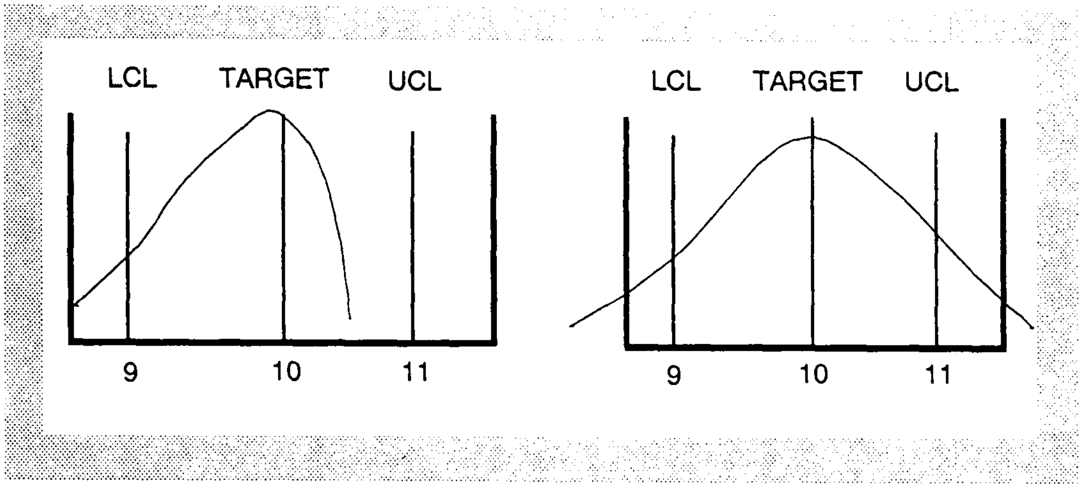


Figure 9. Skewed and Normal Distributions

Figure 10 presents both the conventional approach and Taguchi's loss function. The shaded area is of higher quality because of the narrow grouping of items; the area between the goalposts and the shaded area indicates items that are within specification or tolerance but have a higher loss function and will be less satisfying to the consumer.

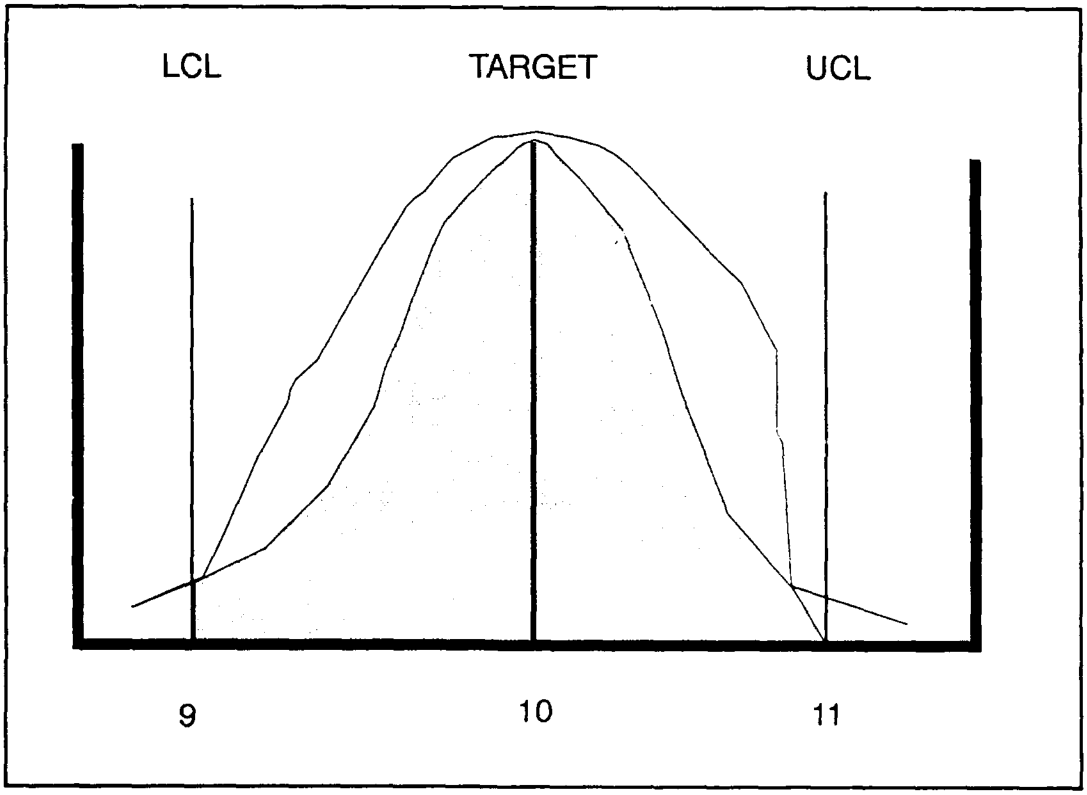


Figure 10. Loss Function

To achieve the close grouping, the process must be under control and a program of continuous improvement must be in place. This is where Deming and Taguchi come together to make a very strong pitch for continuous improvement. The basic message is that better quality is a matter of continuous improvement.[44] Four fundamental concepts can be formulated from Taguchi's work:

1. Designs should be inherently robust to tolerate radical changes in the environment.
2. Low-cost or controllable function should be controlled; not every function need be controlled.
3. Nothing less than the optimum proportions should be specified in product specification sheets.
4. Management's willingness to make economic adjustments to improve quality is key to its success.

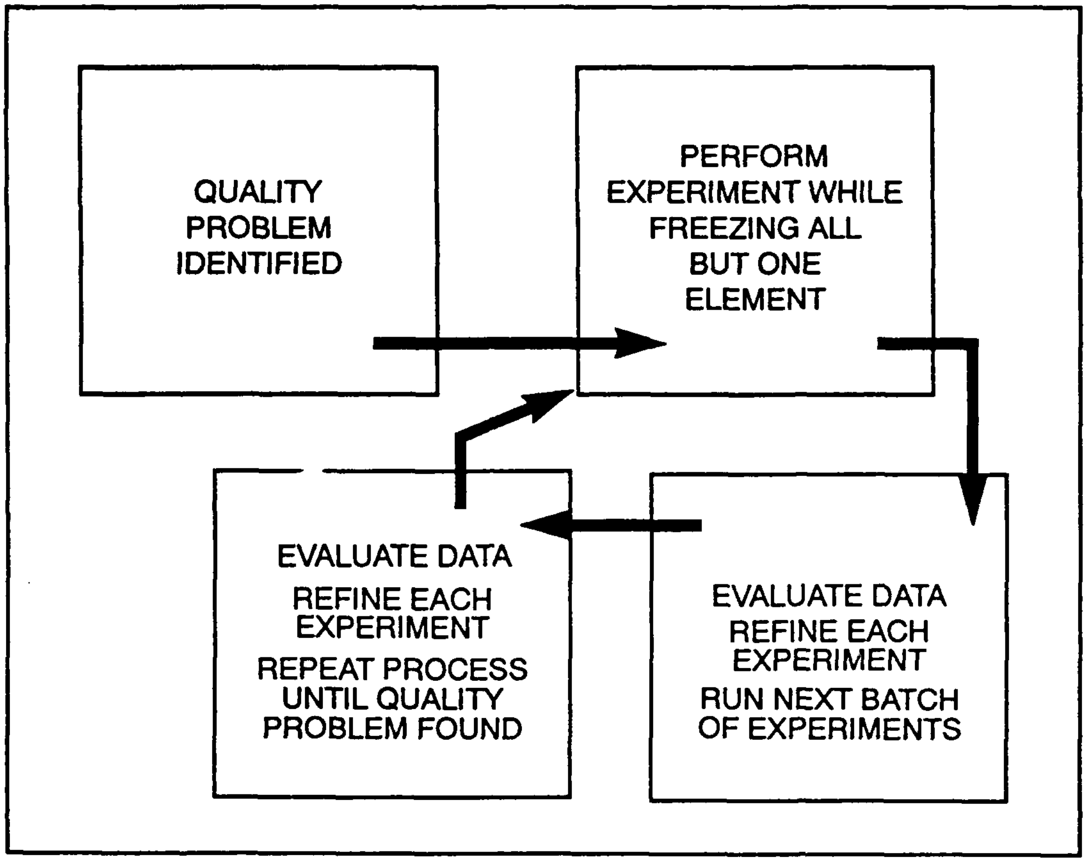
Taguchi's loss function supports the notion that continuous improvement is the principal means to achieve higher-quality products and services. Lower losses achieved through robust designs will vary little from the target value. Robust designs are constructed with superior materials, processes, and workmanship, and they survive in a wide range of environments.

Taguchi is also known for his concepts of problem solving through statistical sampling methods and design of experiments (DOE). The classic DOE process for solving quality problems is to hold all but one variable constant, make a change in that one variable, and determine whether that variable caused the quality problem. A process with as few as seven variables could force quality engineers to run as many as 42 experiments. If the problem cannot be isolated into single variables, the number of possible tests could be as high as 5,040. But Taguchi's procedure reduces this process to a "common sense approach."[45] Figure 11 portrays the classical approach to solving such quality problems; figure 12 portrays the Taguchi method. Taguchi uses the combined experience and intelligence of the system's workers to brainstorm the most likely problems and select the few that hold the greatest promise.

Both of Taguchi's concepts, loss function and design of experiments, are dependent on two common principles of TQM: continuous improvement and management involvement.

Notes

1. Office of Assistant Secretary of Defense for Production and Logistics (OASD P&L) TQM-IPQ Fact Sheet, subject: Total Quality Management, 4 May 1989.
2. A. V. Feigenbaum, *Total Quality Control*, 3d ed. (New York: McGraw-Hill, 1983), 6.
3. *Total Quality Management* (Washington, D.C.: Department of Defense, August 1988), 1.



Source: Adapted from John Holusha, "Improving Quality, The Japanese Way," *New York Times*, 20 July 1988, D7.

Figure 11. Classic Approach

4. Dr Myron Tribus, in *Quality First: Selected Papers on Quality and Productivity Improvement* (Cambridge, Mass.: Massachusetts Institute of Technology, 1987), 4, defines quality as "giving people what they have the right to receive." I have chosen to orient the focus on quality to assert that customers must first clearly establish what their requirements are. After that has been done, quality is what they expect.

5. Thomas R. Stuelpnagel, "Improved US Defense Total Quality Control," *National Defense* 72 (May–June 1988): 43–48; and Thomas R. Stuelpnagel, "Total Quality Management," *National Defense* 72 (November 1988): 57–62.

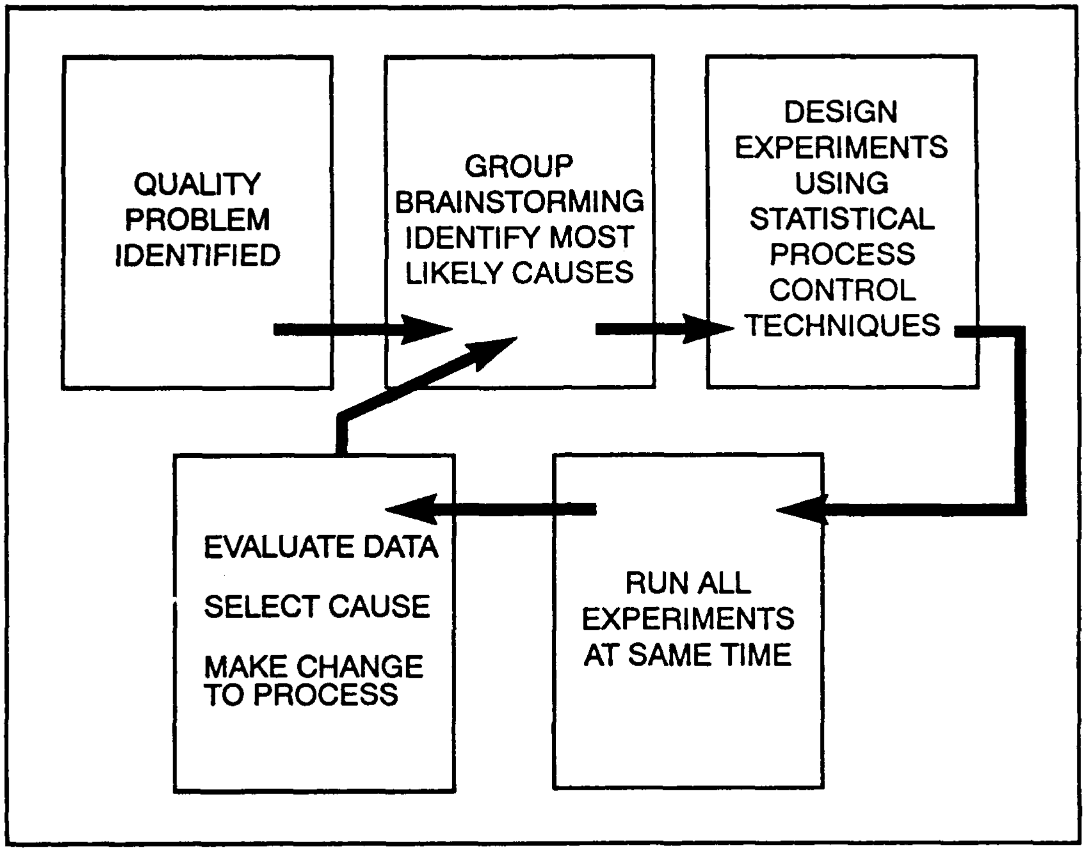
6. Variability distribution will be described in detail later. It is the distribution of defects grouped around a center point. The closer the defects to the center point, or mean, the better the quality. The better the quality through variability reduction, the lower the cost of quality.

7. System members are any employees in an organization, work group, or team who share common processes and goals. System members are labor, staff, and/or management. In the broadest sense, system members include the customer.

8. Stuelpnagel, "Total Quality Management," 4.

9. John A. Betti, "The Quest for Quality: A Key to the Corporate Turnaround at Ford Motor Company," speech excerpted from booklet that had no publishing data.

10. Philip B. Crosby, *Quality Is Free: The Art of Making Quality Certain* (New York: McGraw-Hill, 1979), 22.



Source: Adapted from John Holusha, "Improving Quality, The Japanese Way," *New York Times*, 20 July 1988, D7.

Figure 12. Taguchi Approach

11. H. James Harrington, "A Guideline to Improvement" (Washington, D.C.: Office of the Secretary of Defense, undated). Dr Harrington is president of Harrington, Hurd & Reiker Management Consultants.

12. *Total Quality Management*, 2.

13. DOD 5000.51-G, "Total Quality Management Guide," final draft, vol. 1, 23 August 1989.

14. Quarterly financial management is used here to mean the system employed by many American manufacturers that focuses all activities on the quarterly profit-and-loss statement.

15. Feigenbaum, 14.

16. David A. Garvin, *Managing Quality: The Strategic and Competitive Edge* (New York: Free Press, 1988), 191–97.

17. Feigenbaum, 11.

18. Stuelpnagel, "Total Quality Management," 57–62.

19. Garvin, 78–92.

20. Ibid., 78.

21. Quoted in Garvin, 79.

22. Y. K. Shetty, "Managing Product Quality for Profitability," *SAM Advanced Management Journal* 53 (Autumn 1988): 33–38; Fikra H. Boghossian, "Build Quality In; Don't Inspect It," *SAM Advanced Management Journal* 53 (Autumn 1988): 44–47; Tom Peters,

Thriving on Chaos: Handbook for a Management Revolution (New York: Harper-Row, 1988), 137–40; Norman R. Augustine, *Augustine's Laws: A Top Executive Looks at the Complexities and Conundrums of Today's Business Management and Offers Solutions* (New York: Viking Penguin, 1986), 79–89.

23. Boghossian, 44–47.
24. Augustine, 82.
25. Ibid., 81–82.
26. Garvin, 84.
27. Ibid.
28. Ibid.
29. Crosby, 131–39.
30. Stuelpnagel, "Total Quality Management," 60.
31. Feigenbaum, "Total Quality Control," 4.
32. Deming has been revising his 14 points. I was able to find three different sets. The earliest appears at appendix B.
33. Nancy R. Mann, *The Keys to Excellence: The Story of the Deming Philosophy*, 2d ed. (Los Angeles: Prestwick Books, 1987), 43.
34. Ibid., ii.
35. Mann makes the point that the US agriculture industry has used statistical design of experiments for years and is dominant in the world food market.
36. Quoted in Mann, 134.
37. Ibid.
38. Ibid., 118.
39. Ibid., 126.
40. Glenn E. Hayes, *Quality and Productivity: The New Challenge* (Wheaton, Ill.: Hitchcock Publishing, 1985), 103.
41. Mann, 154–55.
42. DOD 5000.51-G, 31–32.
43. Garvin, 54.
44. John Holusha, "Improving Quality, The Japanese Way," *New York Times*, 20 July 1988, D7.
45. Ibid.

Chapter 3

The Total Quality Management Model

A model is a way to visualize a complex operation or process as simply as possible. The TQM model does that. It portrays the components and the philosophy of total quality.

The model presented was developed from many different sources. The various concepts, although developed independently, have been consolidated to function as a complete system. This system will provide the structure necessary to manage an organization, its people, and its processes to meet customer needs.

The TQM model is made up of 10 components. The first nine are: external customers, strategic requirements, strategic vision, mission analysis, organization, suppliers, internal processes, measurement system, and continuous improvement. These components are connected to each other by the 10th, a two-way communication link that passes information forward through the system and receives information back about the other components. The gateway for passing information throughout the organization is the direction and feedback loop. Direction and feedback in an organization are as important to the execution of the organization's purpose as anything else. In the direction/feedback loop, different types of direction and feedback are reviewed.

The TQM model components are important systems. They must be fully functioning to achieve the greatest value. But the model is very fragile. In fact, its fragility cannot be overemphasized. For that reason, each component is represented by a triangle balanced and wedged by other triangles (fig. 13). On the bottom of the model, two triangles—the measurement system and continuous improvement—support the other triangles. This is intended to underscore the fact that these two components support the others. If they are not strong, the entire quality organization will fall apart.

Each component is represented by a triangle, the three lines of which represent three common themes that permeate the TQM model: continuous improvement throughout every activity, measurement used to improve every activity, and team power used to move the organization to levels that satisfy its customers. The components are covered individually in separate chapters; this section introduces them.[1]

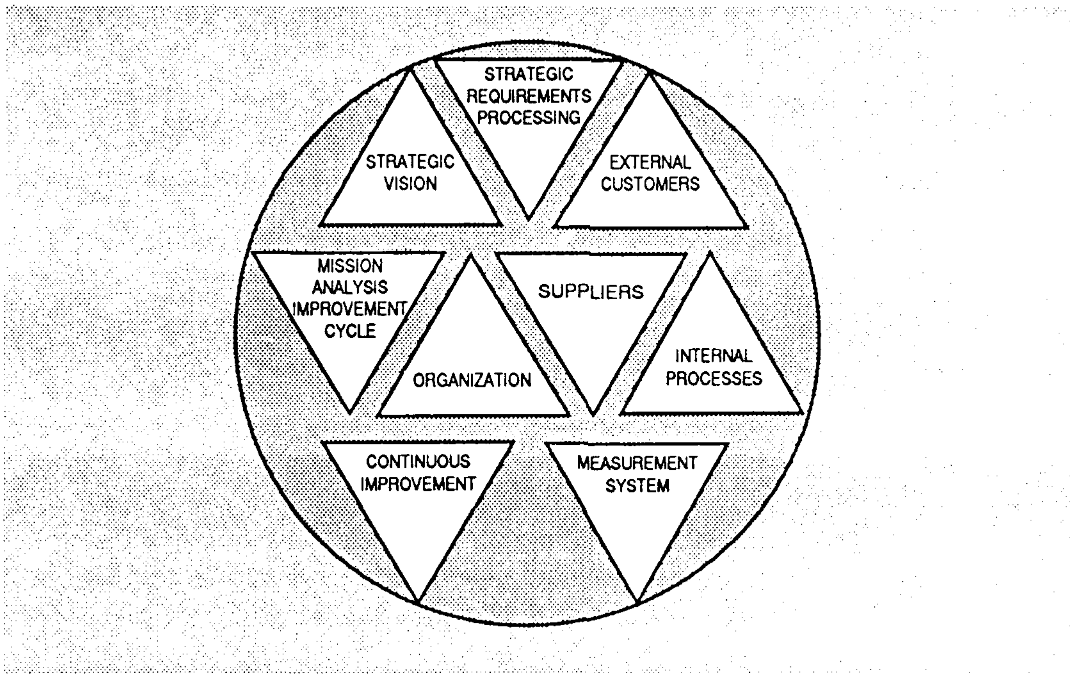


Figure 13. Total Quality Model

External Customers

Any discussion about a total quality organization must start outside the organization, and with an understanding that organizations exist to satisfy their customers. Dividends, financial rewards, passed operational readiness inspections, and other measures of success result from understanding and satisfying the organization's customers. When a total quality organization understands and nourishes its customers, rewards will come to that organization.

A total quality organization understands the relationship between cause and effect. Every activity is focused on the cause of the desired effect. Four areas are emphasized: customer identification, customer perception of quality, customer's requirements, and the customer-organization communication link.[2]

Strategic Requirements

Strategic requirements processing systematically catalogs, identifies, and documents customer requirements. The process combines two previously independent programs in an effort to understand the customer's expectations and convert them into design specifications.

The front end of the process is a project called mission operational characteristics. The body is a program called quality function deployment. Combined, these programs are referred to as strategic requirements processing (SRP).

SRP provides a comprehensive checklist of terms to initiate the requirement definition process and establishes a common point of reference between the product owner and the customer to identify ambiguities that could cause customer dissatisfaction. This system can be used throughout the research and development process, becoming more and more detailed as producer, product, and customer mature. In addition, use of SRP will reduce the development cycle, lower the risk in design, reduce cost, and increase the overall quality of the product.

The single most important aspect of SRP is that it encourages functional teams working together early in the design-and-development process. Functional boundaries that were once established and guarded are broken down through multifunctional teams working together to eliminate potential problems early. SRP encourages systems engineering to work as it is designed to work.[3]

Strategic Vision

Strategic vision guides the destiny of an organization. Established and articulated by the leader of the organization, strategic vision introduces the strategic planning process (SPP). The SPP is the means by which visions are translated into objectives. It is a top-down process and a bottom-up process that encompasses direction, execution, and budget. All members affect the destiny of the total quality organization.[4]

Mission Analysis

Mission analysis is a systematic study of the organization's purpose. The mission analysis improvement cycle (MAIC) takes the total quality organization through a series of steps to identify customers, customer requirements, the organization's requirements of the customer, the process and methods that support these requirements, and a measurement system.

Two other elements are internal customers and external suppliers. MAIC forces the total quality organization to look at the external customer, the internal customer, and the supplier as an integral unit that must continuously work together to identify requirements. These requirements include the organization's requirements of the external customer and the supplier. At the completion of the cycle, data is collected and integrated to identify what is required of each component for the organization to establish excellence.[5]

Organization

Two of the most logical areas for improvement in any organization are design and execution. The organization segment in the TQM model focuses on three aspects of design and execution: people, management structure, and principles.

The people in the organization must be treated with respect and intelligence. The total quality organization is far from the Tayloristic organization of the last century, which required workers to clock in and hang their brains at the door. Every worker is important, and every worker's place in the organization is important. Every worker is competent, and the key to competency is training. Training increases productivity, which increases self-worth, which produces high-performance workers.

High-performance people need an organizational structure that allows them to reach their full potential. The total quality organization uses multifunctional, interdependent teams to achieve continuous improvement and high results.

Ten principles guide and mold the total quality organization to support high-performance people and their customers and to establish a culture that supports continuous improvement.

1. Establish a vision and weave it through every activity in the organization.
2. Establish a strategic planning process that translates the vision into meaningful goals.
3. Establish a cultural philosophy that reflects the high rate of change in a high-performance organization.
4. Organize by teams.
5. Measure everything that is important.
6. Make all business decisions on quality first and second.
7. Create leaders throughout the organization.
8. Establish ownership of every process within the organization.
9. Establish pride, professionalism, and confidence in all employees.
10. Demand total integrity from every level of the organization.[6]

Suppliers

A total quality organization must go beyond its people, its structure, and its customers; it must also look at its suppliers. In the total quality organization, suppliers are reviewed and an understanding is developed that organizations should have a few quality suppliers rather than many low-cost suppliers.

During the process of understanding the importance of single vendors, a set of 30 affirmations is developed to alleviate some of the fears encountered by the procurement people. These 30 affirmations can also be used as a checklist to judge potential vendors.

The final area in the suppliers' element is a review of contracting. The total quality organization challenges the current role of the contracting specialty. An understanding is developed as to why the current approach to contracting cannot work in a total quality organization and how it must change. Management establishes a new philosophy—buy quality first and use statistical process techniques to determine the lowest cost for the best products.

Internal Processes

The total quality management model demands that every process be owned by someone. Only after ownership is found and accepted is it possible to begin the process of improvement. Process owners control their processes and know which directions and changes affect their processes.

When no one has been identified as the process owner, no one takes responsibility for determining the impact of changes. To correct these deficiencies, a total quality organization uses the *internal process improvement model* (IPIM) to identify process owners, develop process effectiveness and efficiencies, establish an assessment system, and foster an environment for process planning. The 21-step model will address all areas to ensure quality outputs.[7]

Measurement System

The measurement system is by far the most controversial area in the total quality model. It proposes that organizations do away with mass inspection and develop a system for process owners to do their own inspections. Inspection adds no value to the product and allows products to continue being produced or services performed when they are out of control.

The process measurement system (PMS) comprises two levels. The first level, the process measurement control system (PMCS), is controlled by the process owner. The second level, the process measurement verification system (PMVS), is an audit function. The process owner's jobs now include inspection and control of the process, and the audit function covers the owner's application of process control tools to plan new processes, solve problems, and maintain statistical control. Various tools have been developed to help process owners, managers, and auditors maintain process control.[8]

Continuous Improvement

Searching for continuous improvement describes the total quality organization. Management actively supports continuous change to accommodate continuous improvement. Through constancy of purpose, the organization adopts a long-term perspective in all activities. The organization looks far to the future, incorporating strategic goals and objectives.

The total quality organization declares that quality is first and that workers will not lose their jobs because they participated in quality improvement. The organization's commitment to quality is demonstrated through reward and recognition for individuals and teams that actively support quality improvement. Advancement is contingent on demonstrated team-leadership skills, competency in statistical process control, and advanced education in quality techniques.

Through a commitment to training, the total quality organization demonstrates its investment in the employee. Such organizations spend a significantly greater part of their budget on training than do traditional organizations.

Continuous improvement is a requirement for every person—not just when it is convenient, but totally—from top management through the entire organization and externally to customers and suppliers. Continuous improvement requires a balance between the expectations of the customer, the work force, and the organization. This balance is achieved through the total quality model (fig. 13).[9]

Notes

1. David A. Garvin, *Managing Quality: The Strategic and Competitive Edge* (New York: Free Press, 1987).
2. Ibid.
3. Jack B. Revelle, *The New Quality Technology: An Introduction to Quality Function Deployment (QFD) and the Taguchi Methods* (Los Angeles: Hughes Aircraft Company, 1988).
4. James T. Ziegenfuss, Jr., *Designing Organizational Futures: A Systems Approach to Strategic Planning with Cases for Public and Non-Profit Organizations* (Springfield, Ill.: C. C. Thomas, 1989).
5. H. James Harrington, "Excellence—The IBM Way," Office of the Secretary of Defense, Washington, D.C., undated.
6. Jay Hall, *Styles of Teamwork Inventory* (The Woodlands, Tex.: Teleometrics International Inc., 1989).
7. William W. Scherkenbach, *The Deming Route to Quality and Productivity: Road Maps and Roadblocks* (Rockville, Md.: Mercury Press, 1988).
8. Brian E. Mansir and Nicholas R. Schacht, *An Introduction to the Continuous Improvement Process: Principles and Practices* (Bethesda, Md.: Logistics Management Institute, August 1989).
9. J. M. Juran, *Juran on Planning for Quality* (New York: Free Press, 1987).

Chapter 4

External Customer

Anyone who thinks the customer isn't important should try doing without him for a period of ninety days.

—Anonymous

The external customer is the reason organizations exist. Without customers, there would be no need for products or services. The customer must be understood and properly maintained to optimize long-term benefits. The first step in maximizing the value of external customers is to identify them. The next step is to understand the customer's perception of quality. The third step is to know the customer's requirements, the last to establish a communication mechanism that continuously transmits information to and from the customer.

Identification of the Customer

All products need customers, and all customers need products; but many products have failed because the real customers were not known or their needs were never satisfied. Producers must constantly stay in touch with the customers' environments, listen to their needs and wants, and keep them informed of ongoing research and development efforts. It is through this continuous process that new products find customers, customers find products that will satisfy their requirements, and products are constantly improved to maintain a satisfied customer base.

Perception of Quality

The organization's understanding of quality may differ from that of the customer. From the TQM perspective, we have defined quality as "what the customer expects to receive." But what does the customer expect to receive? Customer expectations of quality can be defined or categorized in five separate and distinctive ways. David Garvin has classified them as "transcendent," "product-based," "user-based," "manufacturing-based," and "value-based."[1]

1. Transcendent:

"Quality is neither mind nor matter, but a third entity independent of the two . . . even though Quality cannot be defined, you know what it is." (Robert M. Pirsig, *Zen and the Art of Motorcycle Maintenance: An Inquiry into Values* [New York: William Morrow & Co., Inc., 1974], 185, 213.)

"There exists a condition of excellence implying fine quality as distinct from poor quality. . . . Quality is achieving or reaching for the highest standard as against being satisfied with the sloppy or fraudulent." (Barbara W. Tuchman, "The Decline of Quality," *New York Times Magazine*, 2 November 1980, 38.)

2. Product-based:

"Differences in quality amount to differences in the quality of some desired ingredient or attribute." (Lawrence Abbott, *Quality and Competition: An Essay in Economic Theory* [New York: Columbia University Press, 1955], 126–27.)

"Quality refers to the amounts of the unpriced attributes contained in each unit of the priced attribute." (Keith A. Lefner, "Ambiguous Changes in Product Quality," *American Economic Review*, December 1982, 956.)

3. User-based:

"Quality consists of the capacity to satisfy wants." (Corwin D. Edwards, "The Meaning of Quality," *Quality Progress*, October 1968, 37.)

"In the final analysis of the marketplace, the quality of a product depends on how well it fits patterns of consumer preferences." (Alfred A. Kuehn and Ralph L. Day, "Strategy of Product Quality," *Harvard Business Review*, November–December 1962, 101.)

"Quality is fitness for use." (J. M. Juran, ed., *Quality Control Handbook*, 3d ed. [New York: McGraw-Hill, 1974], 2-2.)

4. Manufacturing-based:

"Quality [means] conformance to requirements." (Philip B. Crosby, *Quality Is Free: The Art of Making Quality Certain* [New York: McGraw Hill, 1979], 15.)

"Quality is the degree to which a specific product conforms to a design or specification." (Harold L. Gilmore, "Product Conformance Cost," *Quality Progress*, June 1974, 16.)

5. Value-based:

"Quality is the degree of excellence at an acceptable price and the control of variability at an acceptable cost." (Robert A. Broh, *Managing Quality for Higher Profits* [New York: McGraw-Hill, 1982], 3.)

"Quality means best for certain customer conditions. These conditions are (a) the actual use and (b) the selling price of the product." (Armand V. Feigenbaum, *Total Quality Control* [New York: McGraw-Hill, 1961], 1.)

These five views of quality are generally accepted by most customers. Sometimes, more than one are used at the same time within the same company. This causes conflicts between the company and the customer

and demonstrates why it is important to understand what the customer expects. In addition to different views, quality has different dimensions: performance, features, reliability, conformance, durability, serviceability, aesthetics, and perceived quality.[2]

Performance combines the product-based and user-based approaches to quality. It is relatively easy to determine because it is objectively measured. Weight, speed, capacity, quietness and so forth are some of the criteria used to measure performance. But performance alone is not enough to determine quality; and performance measurements must mean the same and be applied the same way by producer and customer to be of any relevance.

Features are generally considered secondary to the basic function of a product. Features on a car could be an automatic transmission, power steering, and air-conditioning. Sometimes it is difficult to separate features from prime requirements, however; some people consider automatic transmission and air-conditioning to be standard equipment.

As stated in chapter 1, reliability is "the probability that a product will carry out its intended function under specified conditions and for a specified length of time." An airplane engine that is reliable for no more than three hours of operation is of little value in an airplane that is designed for 12-hour missions. On the other hand, an engine with three hours of operation used on two-hour missions may be more than sufficient. Like performance, reliability must match customer needs.

The simplest way to look at quality is through the dimension of conformance—that is, conformance to standards or specifications. Producers control conformance through process control and sampling. But we learned in chapter 1 that conformance alone would not guarantee quality. Through the practice of sampling, products can be released that do not meet customer requirements. Increasing conformance through narrowing variability will directly increase quality.

Durability is the functional life of a product. Durability in its simplest terms is the product's strength. It becomes complicated when a product's design allows for intermittent repairs. When reliability and durability are considered together in the requirements and design process, quality can be greatly improved.

Serviceability is extremely important in some products. Users of light bulbs (who are concerned with durability) have no expectation to service the light bulb when it fails. On the other hand, users of fire engines are concerned with both durability and serviceability because fire protection is decreased when the engine is down for maintenance or repairs. Parts availability is also of concern; and when serviceability is optimized to the user's unique environment, quality is increased.

Aesthetics is the most subjective of the eight dimensions. It is usually measured in terms of smell, taste, sound, and appearance. It is therefore understandable why producers must comprehend the customer's needs and perceptions.

Perceived quality is difficult to develop or design; but once it is associated with a product, its value is great. Perceived quality is developed over time and based on consumer loyalty and opinion. The perception that a particular product is of higher value than a similar product is reinforced through advertising, word of mouth, and reassurance. The perception of quality in past products by the same company is transferred to new products. Producers who understand the value of this subjective dimension build quality into new products to ensure that quality perceptions are reinforced and that the perception of quality is transferred to the new product.

The different dimensions of quality, along with the different ways one may look at quality, make it difficult to satisfy all customers all the time. It is important to understand the customers' perceptions and biases, and the surest way to achieve this is through a well-detailed and documented development of customer requirements and constant feedback.

Customer Requirements

Customer requirements constitute the voice of the customer in the design and development process. How well they are understood will be reflected in customer satisfaction or dissatisfaction. To increase the chances of understanding what the customer wants, a process called strategic requirements processing (SRP) is used. SRP defines quality from the customers' point of view; customer requirements are directly communicated to the design and development process. More importantly, customer perceptions of quality are documented in a set of detailed and elaborate diagrams that everyone involved can examine.

Communication Link

The communication link between organization and customer is most important. The linkage serves five functions: (1) finding the customer(s), (2) documenting and validating the customers' requirements, (3) obtaining feedback during the design and development process, (4) acknowledging product acceptance, and (5) obtaining feedback after the product is in use. These elements should be developed to the maximum extent possible.

In the product development cycle, it is important to have "feelers" in the environment that can find potential customers and bring new requirements to the organization. As requirements and customers are identified, the communication link serves the purpose of refining and documenting the customers' requirements. In large organizations, the environmental feelers continue to develop more leads for more new products or upgrades to existing products.

It is essential to establish formal and informal lines of communication that provide feedback directly to the design engineers as the product is being developed. It is far easier to correct a misunderstood requirement in the early stages of development than during testing or fielding of the product. The formal lines of communication include design-review meetings where requirements serve as a road map. SRP serves two important purposes: it reinforces the validated requirements already documented, and it educates both the customer's and the producer's new employees who may not be fully cognizant of the "real" requirements. Other formal communications include document reviews, test reports, and change-order statusing—and the customer must be made a part of the process. In a good customer-producer environment, both are on the same side of problems and solutions.

Informal communication also provides valuable insight into the workings of both the customer and the producer. Two important links are establishment of on-site representatives and electronic connectivity. Although some people could argue that both of these links are formal—or at least that establishing them will require some formalities between the two organizations—they must be considered informal because they lack the checks and balances of more formal systems that are reviewed by responsible management. This, however, should not diminish their usefulness. They provide a plethora of valuable information that is otherwise difficult to get through formal means.

On-site Representatives

On-site representatives should be considered for any large development. Both the producer's and the customer's organizations should be represented. These representatives should be integrated into normal operations as much as possible. (There are some exceptions of course—e.g., budget and strategic planning.) The preferred placement of these representatives is where they can understand the problems and constraints faced regularly by their host. But when these representatives are hampered by bureaucratic rules that preclude free and open discussions with the host employees, it is quite possible that ideas and solutions will never be identified.

Electronic Connectivity

Electronic connectivity between the producer's and the customer's computer systems is an easy and efficient means to communicate. With this type of connectivity, information is quickly distributed. One such network was set up between program office, customers, suppliers, and prime contractors. A second was set up between a program office in Boston and a prime contractor in Dallas. The first effort was not successful; the second was successful. The difference was middle management involvement. In the successful operation, management saw the electronic linkage as an

extension of the administrative and communications system. Management in the unsuccessful operation saw the linkage as a challenge to management authority and control. The unsuccessful operation was much slower in discovering and resolving issues.

Producers and customers need to initially establish goals for successful usage of informal communications. If they agree that the benefits are worth the effort and cost, then a set of procedures is warranted. As with other processes in a total quality organization, measurement and process reviews should be conducted to continuously improve communications.

In a total quality organization, the customer is the total reason for existence. Every service or product should be what the customer expects to receive, and its requirements should be documented. In a total quality organization, requirements are documented through strategic requirements processing.

Notes

1. David A. Garvin, *Managing Quality: The Strategic and Competitive Edge* (New York: Free Press, 1987), 40–41.
2. Ibid., 40–60.

Chapter 5

Strategic Requirements Processing

The secret to customer satisfaction is knowing what the customer expects and giving him what he wants.

—Anonymous

The focus of a quality organization is on the customer, and the focus of the customer is on requirements. The customer's requirements must be presented in a way that is understandable to the cost analyst, who provides a cost estimate for the work; to the marketeer, who must bring the requirements into the organization; to the engineer, who must convert objective and subjective requirements into products; and to the tester, who must measure conformance to requirements. If a requirement is misunderstood at any time in this process, the customers will probably not receive what they expect.

This chapter combines two concepts—mission operation capabilities (MOC) and quality function deployment (QFD)—into an all-inclusive requirements process called strategic requirements processing. SRP is an iterative process that can be used to combine requirements and convert them into an orderly set of documents understood by a multifunctional group.

Mission Operational Capabilities

MOC was developed by the R&M 2000 organization (USAF/LE-RD), Synergy, Inc., and the ANSER Corp.[1] The purpose of MOC is to focus attention and understanding on user requirements by defining, early in the process, the elements of requirements. MOC is a list of common terms of reference in a hierarchical order—for example, from cargo aircraft down to takeoff and landing. Figure 14 provides an example of how a MOC diagram would look for the C-17 cargo aircraft.

The customers' first responsibility is to develop their requirements in such a way as to avoid ambiguities and generalizations that can be easily misunderstood. Requirements can best be developed through the MOC diagram process. The process starts with the upper-level requirement and is developed to the lowest level required. This process forces a description of the customer's needs and expectations in measurable terms. Next, the MOC diagram is presented to the producer for review, understanding, and

CARGO AIRCRAFT MOC DIAGRAM

MISSION

AIRLAND/AIRDROP/EXTRACTION

MISSION PROFILES

CAPABILITY

INITIAL OPERATIONAL CAPABILITY

FULL OPERATIONAL CAPABILITY

DESIGN TO LIFE-CYCLE COST

A. DELIVERY PAYLOAD

1. OUTSIZE

(A) ROLLING STOCK

(1) NUMBER
(2) SIZE
(3) WEIGHT
(4) ETC.

(B) ETC.

2. OVERSIZE

____

____

3. PARATROOPS

(A) EQUIPPED

(1) COMBAT
(2) HIGH ALTITUDE LOW OPENING
(3) ETC.

B. OPERATING PERFORMANCE

Figure 14. MOC Diagram

detailing. The producer takes these requirements and begins the process of adding engineering specifics to the customer's performance requirements.

The process is quite simple and straightforward. Once set up, it can be used over and over again, especially if it is developed electronically in a data

base management system. MOC diagrams can be used to modify components of larger systems or as a way of describing entirely new systems. The reason it has not been done previously is that it takes quite a lot of up-front time the first time around. However, its usefulness is well worth the up-front expenditure.

Synergy reported that if MOC were used by all Air Force commands to describe missions and system requirements, the quality of products produced would improve. The use of MOC diagraming would accomplish the following:

- provide a comprehensive checklist of terms to establish performance requirements;
- provide a common point of reference to develop requirements documentation;
- aid in the compression of the acquisition cycle; and
- improve the clarity of information flowing between the customer, the acquisition agency, and the producer.[2]

MOC diagraming develops the "what" customers expect to receive. The next (equally important) elements in the SRP are the "how," "level of significance," and "analysis" of each of the WHATs. This is done through building a "house of quality" by using the tools of QFD.

Quality Function Deployment

House of quality, a requirements system developed in Japan, is part of a management approach called quality function deployment—a collection of planning and communication practices that assists organizations to better coordinate requirements between multifunctional groups. "The house of quality is a kind of conceptual map that provides the means for interfunctional planning and communications."[3]

Building the house of quality, like building any house, is a step-by-step process starting with a foundation and becoming increasingly detailed. There are 11 steps in the process:

1. Define customer requirements (the WHATs)
2. Determine design requirements (the HOWs)
3. Develop relationships (levels of significance)
4. Define/assign weighting factors (levels of significance)
5. Define correlation matrix (levels of significance)
6. Prioritize (analysis/algorithms)
   a. Develop weights
   b. Develop key elements
7. Develop other data elements (examples)
8. Develop design matrix (repeat steps 1–7)
9. Develop product characteristics matrix (repeat steps 1–7)
10. Develop manufacturing/purchasing matrix (repeat steps 1–7)

11. Develop control verification matrix (repeat steps 1–7)[4]

The steps required to build a house of quality will be discussed in the following pages. Steps 1 through 7 are generic steps in the development of five documents in QFD. The first document created is referred to as the "voice of the customer" or the customer requirements matrix. This matrix establishes what the customer wants and how the producer will provide it. This is commonly referred to as the "WHATs" and the "HOWs."

After the requirements matrix has been developed, design data (the HOWs) become the WHATs in the design matrix, and new HOWs are developed. This waterfall effect is carried forward into the product characteristics matrix, then the manufacturing/purchasing matrix, and finally the control/verification matrix. If needed, this waterfall effect can be shortened or lengthened. Regardless of its length, the house of quality always starts with the voice of the customer.

Step 1—Defining Customer Requirements

This is the critical step. It must capture the true customer expectations in a manner that is understandable so that the remaining steps are based on correct interpretation of information. Completion of this process is a good start toward building a quality house.

Requirements are divided into three categories: primary, secondary, and tertiary (fig. 15). They are then listed on the left of the house of quality and referred to as customer requirements (fig. 16).[5] In addition, it is important to go beyond the expectations and list the customer's quality perceptions. As we learned in chapter 4, customers have many different perceptions of quality. Documentation here will avoid problems later—now is the time to validate perceptions.

Step 2—Determine Design Requirements (the HOWs)

Step 2 documents the design characteristics that are needed to meet customer requirements. The design characteristics are developed by various members of the organization, usually led by the engineering team. The design characteristics are placed along the top horizontal row of the house. The design characteristics, sometimes referred to as engineering characteristics, describe customer requirements in engineering terms.

Design requirements should be characterized in a way that is understandable to the designer, and they must be expressed in measurable terms. If they are not, they will become trivial and lose significance.

After the design requirements have been documented across the top of the house, relationships must be developed between customer requirements and design requirements. This area, called the relationship matrix or the planning matrix, is developed in steps 3 and 4.

THE WHATS CUSTOMER REQUIREMENTS		
PRIMARY	**SECONDARY**	**TERTIARY**
OPERATING CHARACTERISTICS	TAKEOFF AND LANDING	TAKEOFF PERFORMANCE
		LANDING PERFORMANCE
	AERODYNAMIC PERFORMANCE	RANGE
		MAXIMUM WEIGHT
	ASSURED CLOSURE TIMES	FLYING QUALITY
		SURVIVABILITY
	DELIVERY PAYLOADS	ROLLING STOCK
		OVERSIZE
		BULK
		COMBINATIONS
	PASSENGERS	TROOPS
		PATIENTS
	SPECIAL MISSIONS	ABCCC
		IRON LUNG
		SOF

Legend: ABCCC - AIRBORNE BATTLEFIELD COMMAND AND CONTROL CENTER
SOF - SPECIAL OPERATIONS FORCES

Figure 15. Customer Requirements

Step 3—Develop Relationships (Levels of Significance)

When customer requirements and design requirements come together, they form a matrix that describes the relationships they have to one another and indicates the planning that must occur to achieve customer satisfaction. The interior of the house is filled with symbols that represent the relationships between customer requirements and engineering requirements (fig. 17). The intersections of WHATs and HOWs are reviewed and relationships are arrived at through consensus. The appropriate symbols are then placed in the intersections of the requirements matrix (fig. 18).

In most cases relationships exist between requirements, but there will be times when no relationship exists. If there are too many blanks in the matrix or in one particular area, check the design requirements for ac-

THE HOWS

DESIGN REQUIREMENTS

NOISE	LEVEL 2 MAINTENANCE	SPECIAL EQUIPMENT	MATERIALS HANDLING EQUIPMENT	RUNWAY	ELECTRONIC COUNTERMEASURES

Figure 16. Design Requirements

curacy. Some of these requirements may be distorting the matrix. If so, they must be corrected.

Visible patterns should portray the dominant customer requirements and design requirements, and should show where the customer and design requirements are dominant in the same element. These correlations are easily spotted. From a designer's perspective, they represent the priority

⊙	INDICATES A STRONG RELATIONSHIP
○	INDICATES SOME RELATIONSHIP
△	INDICATES A SMALL RELATIONSHIP
NO MARK	INDICATES NO RELATIONSHIP

Figure 17. Quality Relationship

CUSTOMER REQUIREMENTS			DESIGN REQUIREMENTS					
PRIMARY	SECONDARY	TERTIARY	NOISE	LEVEL 2 MAINTENANCE	SPECIAL EQUIPMENT	MATERIALS HANDLING EQUIPMENT	RUNWAY	ELECTRONIC COUNTERMEASURES
OPERATING CHARACTERISTICS	TAKEOFF AND LANDING	TAKEOFF PERFORMANCE	⊙		△		⊙	
		LANDING PERFORMANCE	○	⊙	△		⊙	
	AERODYNAMIC PERFORMANCE	RANGE					○	△
		MAXIMUM WEIGHT	△				○	○
	ASSURED CLOSURE TIMES	FLYING QUALITY	△	△				○
		SURVIVABILITY			○			⊙
	DELIVERY PAYLOADS	ROLLING STOCK			○	⊙		
		OVERSIZE			○			
		BULK			△	⊙		
		COMBINATIONS				⊙		
	PASSENGERS	TROOPS	○		⊙			○
		PATIENTS	⊙		⊙	△		○
	SPECIAL MISSIONS	ABCCC	○		△			
		IRON LUNG	⊙		⊙	△		
		SOF						⊙

Legend:

⊙ INDICATES A STRONG RELATIONSHIP
△ INDICATES A SMALL RELATIONSHIP
○ INDICATES SOME RELATIONSHIP
NO MARK INDICATES NO RELATIONSHIP

Figure 18. Relationships between the Elements

design characteristics where trade-offs usually will not occur. In other areas, where little relationship exists, the potential for trade-off is dependent on the importance the customer places on the elements and the risk the element represents.

Step 4—Define/Assign Weighting Factors (Levels of Significance)

Two new columns are added to the quality house: customer interest and design requirements' risk (fig. 19). Use the same symbols and the same process to arrive at the values. To determine customer importance, rely on reviews with the customer or on customer surveys.

Step 4 is complete when the quadrants have been reviewed and symbols have been placed against tertiary and design elements that have relationships to the components. The new data must be reviewed for determination of whether it reflects reasonable relationships to requirements and risk. The next step in this process is to put the roof on the house of quality. The roof relates design requirements to each other without considering customer requirements.

DESIGN REQUIREMENTS

CUSTOMER REQUIREMENTS

PRIMARY	SECONDARY	TERTIARY	CUSTOMER INTEREST	NOISE	LEVEL 2 MAINTENANCE	SPECIAL EQUIPMENT	MATERIALS HANDLING EQUIPMENT	RUNWAY	ELECTRONIC COUNTERMEASURES
OPERATING CHARACTERISTICS	TAKEOFF AND LANDING	TAKEOFF PERFORMANCE	⊙	⊙		△		⊙	
		LANDING PERFORMANCE	⊙	○	⊙	△		⊙	
	AERODYNAMIC PERFORMANCE	RANGE	○					○	△
		MAXIMUM WEIGHT	△	△				○	○
	ASSURED CLOSURE TIMES	FLYING QUALITY		△	△				○
		SURVIVABILITY	○			○			⊙
	DELIVERY PAYLOADS	ROLLING STOCK	△			○	⊙		
		OVERSIZE	⊙			○			
		BULK				△	⊙		
		COMBINATIONS	○				⊙		
	PASSENGERS	TROOPS	○	○		⊙			○
		PATIENTS	△	⊙		⊙	△		○
	SPECIAL MISSIONS	ABCCC		○		△			
		IRON LUNG		⊙		⊙	△		
		SOF	⊙						⊙
		RISK		⊙		○	△		⊙

Legend:

⊙ INDICATES A STRONG RELATIONSHIP

○ INDICATES SOME RELATIONSHIP

△ INDICATES A SMALL RELATIONSHIP

NO MARK INDICATES NO RELATIONSHIP

Figure 19. Weighting Factors

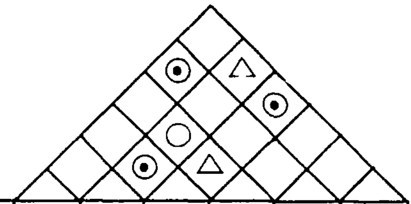
Step 5—Define Correlation Matrix (Levels of Significance)

Technical interrelationships are also indicated by symbols placed in quadrants (fig. 20). The correlation matrix atop the house assists the engineering team to specify those areas that will require improvement. Since one element may affect others, all must be designed or developed to impart benefits to the others. The roof contains the most important data relative to meeting customer expectations.

A significant amount of information has now been collected—too much to be useful without weighted values to help determine the most significant and least significant requirements.

Step 6—Prioritize (Analysis/Algorithms)

Step 6 has two stages: first, weights (relative and absolute) are developed for each design requirement, and then key elements are identified based on the values arrived at in developing the design weights (fig. 21).



CUSTOMER REQUIREMENTS

PRIMARY	SECONDARY	TERTIARY	CUSTOMER INTEREST	NOISE	LEVEL 2 MAINTENANCE	SPECIAL EQUIPMENT	MATERIALS HANDLING EQUIPMENT	RUNWAY	ELECTRONIC COUNTERMEASURES
OPERATING CHARACTERISTICS	TAKEOFF AND LANDING	TAKEOFF PERFORMANCE	⊙	⊙		△		⊙	
		LANDING PERFORMANCE	⊙	○	⊙	△		⊙	
	AERODYNAMIC PERFORMANCE	RANGE	○					○	△
		MAXIMUM WEIGHT	△	△				○	○
	ASSURED CLOSURE TIMES	FLYING QUALITY		△	△				○
		SURVIVABILITY	○			○			⊙
	DELIVERY PAYLOADS	ROLLING STOCK	△			○	⊙		
		OVERSIZE	⊙			○			
		BULK				△	⊙		
		COMBINATIONS	○				⊙		
	PASSENGERS	TROOPS	○	○		⊙			○
		PATIENTS	△	⊙		⊙	△		○
	SPECIAL MISSIONS	ABCCC		○		△			
		IRON LUNG		⊙		⊙	△		
		SOF	⊙						⊙
		RISK		⊙		○	△		⊙

Legend:

⊙ INDICATES A STRONG RELATIONSHIP

○ INDICATES SOME RELATIONSHIP

△ INDICATES A SMALL RELATIONSHIP

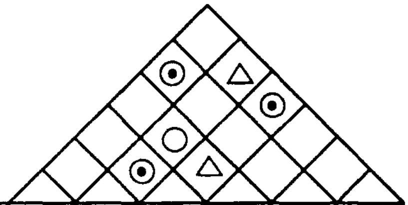
NO MARK INDICATES NO RELATIONSHIP

Figure 20. Correlation Matrix

a. Development of Weights. The objective of this step is to determine the most significant elements that will require persistent attention. This is done by taking calculations for absolute weight and relative weight.

Absolute weight:

- For each HOW, sum the relationship value for each WHAT.
- Perform this process for each HOW across the matrix.
- After the HOWs have been summed, rank them from highest to lowest and enter the ranks in the "relative" column.



CUSTOMER REQUIREMENTS

PRIMARY	SECONDARY	TERTIARY	CUSTOMER INTEREST	NOISE	LEVEL 2 MAINTENANCE	SPECIAL EQUIPMENT	MATERIALS HANDLING EQUIPMENT	RUNWAY	ELECTRONIC COUNTERMEASURES
OPERATING CHARACTERISTICS	TAKEOFF AND LANDING	TAKEOFF PERFORMANCE	⊙	⊙		△		⊙	
		LANDING PERFORMANCE	⊙	○	⊙	△		⊙	
	AERODYNAMIC PERFORMANCE	RANGE	○					○	△
		MAXIMUM WEIGHT	△	△				○	○
	ASSURED CLOSURE TIMES	FLYING QUALITY		△	△				○
		SURVIVABILITY	○			○			⊙
	DELIVERY PAYLOADS	ROLLING STOCK	△			○	⊙		
		OVERSIZE	⊙			○			
		BULK				△	⊙		
		COMBINATIONS	○				⊙		
	PASSENGERS	TROOPS	○	○		⊙			○
		PATIENTS	△	⊙		⊙	△		○
	SPECIAL MISSIONS	ABCCC		○		△			
		IRON LUNG		⊙		⊙	△		
		SOF	⊙						⊙
		RISK		⊙		○	△		⊙
	WEIGHTS	RELATIVE							
		ABSOLUTE							
	KEY ELEMENTS								

Legend:
⊙ = 5
○ = 3
△ = 1

Figure 21. Prioritize Design Requirements

Relative weight:
- For each HOW, sum the relationship value for each WHAT.
- Multiply the sum for each HOW by the risk value.
- Perform this process for each HOW across the matrix.
- After the HOWs have been summed, rank them from highest to lowest and enter the ranks in the "absolute" column.

b. Development of Key Elements. Key elements are those that designers and engineers will place the highest priority on in the development process. To determine key elements, arrange data from the HOWs on horizontal lines, left to right. On the first horizontal line, list relative weights for HOW. Then list the absolute weights on the next horizontal line. When this has been

done, sum each of the columns. The key values are then determined by ranking the sums of each, with a "1" representing the highest sum, a "2" representing the next, and so forth until each column has a ranking (table 5).

Table 5

Key Elements

Relative Weight	155	0	93	18	16	140
Absolute Weight	31	6	31	18	16	28
Sum	186	6	124	36	32	168
Key Elements	1		3			2

There are no magic equations or ratios to determine where key values begin or end. Most assuredly, however, those elements with a ranking in the upper third are key elements. Determining when elements become ordinary is something that only experience with customer, product, and process will establish.

Step 7—Develop Other Data Elements (Examples)

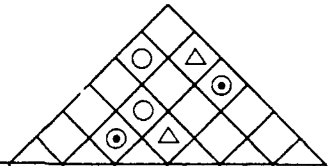
Develop other columns on the right-hand side of the relationship matrix. These columns are for areas where the organization has the most to gain or lose. Keep attention focused on these elements. In the example, cost, level of effort, and quality perceptions are used. In some house of quality applications, a column for benchmarking the organization's capability against that of its competitors is listed (BMAC) (fig. 22).

Steps 8–11—Developing the Design Matrix, Product Characteristics Matrix, Manufacturing/Purchasing Matrix, Control Verification Matrix, and Others

Develop the design matrix by changing the HOWs developed from the requirements matrix into the WHATs, or requirements, and developing a new house of quality for design effort. Continue this process until all the matrixes have been completed.

Benefits and Drawbacks of Quality Function Deployment

Using QFD entails three drawbacks: (1) it requires extensive training, (2) it requires a large computer base, and (3) it is laborious.[6] QFD requires an



CUSTOMER REQUIREMENTS

PRIMARY	SECONDARY	TERTIARY	CUSTOMER INTEREST	NOISE	LEVEL 2 MAINTENANCE	SPECIAL EQUIPMENT	MATERIALS HANDLING EQUIPMENT	RUNWAY	ELECTRONIC COUNTERMEASURES	COST	EFFORT	QUALITY	BENCHMARKING AGAINST COMPETITORS
OPERATING CHARACTERISTICS	TAKEOFF AND LANDING	TAKEOFF PERFORMANCE	⊙	⊙		△		⊙					
		LANDING PERFORMANCE	⊙	○	⊙	△		⊙					
	AERODYNAMIC PERFORMANCE	RANGE	○					○	△				
		MAXIMUM WEIGHT	△	△				○	○				
	ASSURED CLOSURE TIMES	FLYING QUALITY		△	△				○				
		SURVIVABILITY	○			○			⊙				
	DELIVERY PAYLOADS	ROLLING STOCK	△			○	⊙						
		OVERSIZE	⊙			○							
		BULK				△	⊙						
		COMBINATIONS	○				⊙						
	PASSENGERS	TROOPS	○	○		⊙			○				
		PATIENTS	△	⊙		⊙	△		○				
	SPECIAL MISSIONS	ABCCC		○		△							
		IRON LUNG		⊙		⊙	△						
		SOF	⊙						⊙				
		RISK		⊙		○	△		⊙				
	WEIGHTS	RELATIVE											
		ABSOLUTE											
	KEY ELEMENTS												

Legend:
⊙ = 5
○ = 3
△ = 1

Figure 22. Other Important Data Elements

extensive amount of training in the areas of team interaction and dynamics, requirements, decomposition and analysis, and customer requirements interpretation. Also, additional training may be needed in operational analysis, Taguchi techniques, and electronic data base creation, modification, and programming.

Using the system for more than 30 customer requirements and developing the house of quality through all five levels could easily require over 3,000 data elements. A data base management system (DBMS) is the most efficient system for developing, maintaining, and manipulating this information. If the organization is computer-literate and possesses expertise in DBMS, this drawback can be overcome.

Finally, QFD is laborious; but then so is the entire industrial process. The difference is that with QFD the labor comes early in the program as compared to the American approach, which concentrates most of its quality enhancement time in the latter phases of the product's life cycle (fig. 23).

QFD is a systematic, structured, and organized way to document and record varying levels of requirements. More advantages have been found

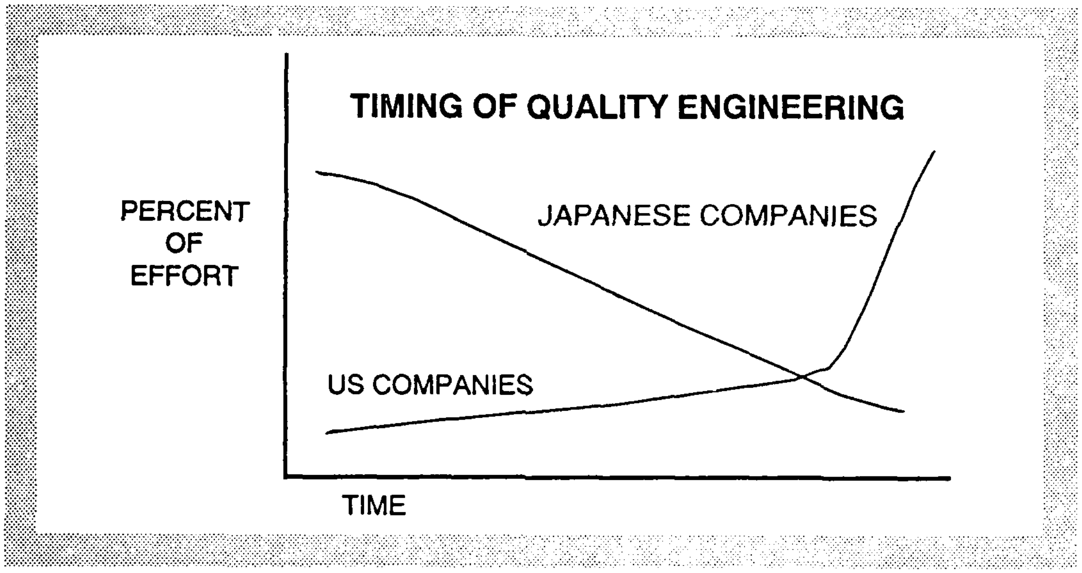


Figure 23. Two Approaches

in its use (table 6). The process assures that the characteristics developed by the customer are equated to design requirements in sufficient detail to meet customer expectations. Because each requirement must be addressed, prioritized, and analyzed, it is difficult to miss any significant requirements. Thoroughness in the requirements development process is almost assured.

Table 6

Advantages and Disadvantages

Advantages

- Systematic and structured
- Assures that product characteristics equate to customer requirements
- Avoids omissions resulting from oversight
- Avoids under- and over-specification
- Maps customer requirements
- Is as sophisticated or simplistic as you care to make it
- Identifies important characteristics that must be controlled
- Produces a documentation trail

Disadvantages

- Requires extensive training
- Is laborious
- Requires large computer data base

Source: Jack B. Revelle, *The New Quality Technology: An Introduction to Quality Function Deployment (QFD) and the Taguchi Methods* (Los Angeles: Hughes Aircraft Company, 1988), G-2 and G-3.

Understanding the relative importance of each component helps to avoid over- and under-specification. Requirements that have the strongest relationship will have the more detailed specifications; requirements that possess little or no relationship will have minimal specification.

QFD can be used to develop new products or to implement a strategic vision. Its concepts and methodology allow for tailoring that can make it very sophisticated or for sketching out a simple product on a single sheet of paper. Complexity depends on the application. Because the methodology is straightforward, all functional areas in an organization can use it and understand it.

Building a house of quality through the QFD process will identify important customer and engineering characteristics that warrant close attention. Finally, QFD has proven to result in fewer start-up problems and lower cost.

Strategic Requirements Processing in a TQM Organization

As we learned in the beginning of this chapter, building a MOC diagram is a detailed and time-consuming process. Nevertheless, it provides an outstanding starting point: listing the WHATs in the house of quality.

As the house of quality is built, strategic requirements processing provides information that internal customers need in developing processes and measurements to ensure that external customers' expectations will be met. SRP provides a uniform approach to requirements documentation. Other processes—such as cost estimation, parts specification, machine requirements, and human resource development—can also use SRP.

SRP touches each element of the TQM model by providing the voice of the customer, regardless of whether it is the chief executive officer, an external customer, an internal customer, a supplier, or a tester. When SRP is used across the organization, it promotes a team approach by breaking down functional barriers. People begin to think about common requirements and customer expectations.

Notes

1. "R&M 2000: Support Command Development of R&M Terms and Definitions through Logic Tree and Translation Matrix Approach," Technical Report, contract no. F49642-85-D0029, Task 5, 11 May 1989, written and produced in Washington, D.C., by Synergy, Inc., for USAF/LEX.
2. Ibid., 1-1 through 1-2.
3. John R. Hauser and Don Clausing, "The House of Quality," *Harvard Business Review* 66, no. 3 (May–June 1988): 63–73.
4. Jack B. Revelle, *The New Quality Technology: An Introduction to Quality Function Deployment (QFD) and the Taguchi Methods* (Los Angeles: Hughes Aircraft Company, 1988), E1 through E15.
5. Ibid., G-5.
6. Ibid., G-9.

Chapter 6

Strategic Vision

Destiny is not a matter of chance; it is a matter of choice.

—Anonymous

The organization's vision provides not only the foundation of the organization, but the course and direction for all future activities of the organization and its people. Vision is the inspiration in good times that continuously pushes employees to greater and greater highs; in bad times it is the beacon that guides the organization out of adversity and choppy waters and into prosperity and calm waters. Vision provides balance for the organization to continuously improve and take risks, certain that the foundation will always be there for support. Vision is a powerful instrument in a total quality organization.

In attempting to define vision, we can look at two different approaches: the abstract approach, which conjures up images of good and powerful forces that work to keep the organization functioning; and the directional approach, which guides the organization (table 7). These approaches provide a foundation to build upon.

Table 7

Two Approaches to Vision

Abstract Approach

"Visions are aesthetic and moral—as well as strategically sound."

Tom Peters, *Thriving on Chaos: Handbook for a Management Revolution* (New York: Alfred A. Knopf, Inc., 1988).

"Vision is a mental journey from the unknown to the known, creating the future from a montage of current facts, hopes, dreams, danger, and opportunities."

Craig R. Hickman and Michael A. Silva, *Creating Excellence: Managing Corporate Culture, Strategy, and Change in the New Age* (New York: New American Library Books, 1984).

Directional Approach

"The framework which guides those choices that determine the nature and direction of an organization."

Benjamin B. Tregoe et al., *Vision in Action: Putting A Winning Strategy to Work* (New York: Simon and Schuster, 1989).

"Visions are both offensive and defensive skills. On one hand, they chart the course that creates change, and on the other, help you respond to external changes."

Craig R. Hickman and Michael A. Silva, *Creating Excellence: Managing Corporate Culture, Strategy, and Change in the New Age* (New York: New American Library Books, 1984).

Vision in a total quality organization must take into consideration that the organization is continuously changing and improving. It must therefore provide stability for the changemakers. The total quality organization is breaking down barriers between functional units, and the vision must support both change and the employees making change. It must be flexible enough to avoid constraining creativity and ingenuity while maintaining the overall focus and direction of the organization.

Vision Defined

In the total quality organization, vision is defined as *the images employees have about where the organization has been, what it did well, the mistakes it made, where it is now, where improvement is needed, where it should be in the future, and how it will get there—through a common strategy, a common culture, and dedicated people.*

Vision in a total quality organization is from the employees' point of view. This is very different from other vision definitions that have their reference at the management level or with some third person speaking for the organization. A total quality leader creates the vision, based on where the organization is going or needs to go, but it is established in such a way that it transfers to the organization and its employees. Ownership becomes personal; and employees guard, defend, and nurture the vision. At the same time, because the vision is so easily transferable, all employees can feel a sense of freedom to take risks, make changes, and ask questions. An effective vision in a total quality organization should satisfy the following basic requirements:

1. See what the organization is capable of and where the organization needs to go. It must capitalize on those areas where the organization can be out in front of the competition.
2. See where and why the organization failed in the past and how to correct the discrepancies.
3. See where the organization was excellent in the past and how to capitalize on those capabilities.
4. Be woven throughout the organization; it must guide every process, decision, and outcome.
5. Define acceptable behavior, activities, and decisions.
6. Inspire the employees to understand the customers and meet their needs.
7. Take into consideration what the organization actually is and what employees and customers believe it to be.
8. See how the organization differs from all others and how to capitalize on its special capabilities.
9. Be understood by worker and manager alike; be free of ambiguities.

10. Beyond all other requirements, the vision must allow employees to do what is needed in a changing and dynamic environment.

11. Allow customers to work with, and participate in, the organization because it is in their long-term interest to do so.

12. See how to prepare the organization to meet the challenges of the future—the next five years, 10 years, and beyond.

It is sometimes hard to separate the vision from the visionary. It takes a dynamic and charismatic visionary to be able to fully comprehend the organization—its strengths, weaknesses, and culture—and to shape a vision which will lead that organization to grandeur. But a visionary who reads the culture of an organization wrong, doesn't understand the organization's strengths, or inherits someone else's vision, can cause havoc.

Inheriting someone else's vision is a problem in large bureaucracies. Given the push for organizations to adopt the TQM philosophy and the mobility of the bureaucracy's middle and upper management, that someone will end up with someone else's vision is inevitable. In this case, it is even more important that the vision be woven through the fabric of the organization. New leaders must be immersed in the culture of the organization and must accept ownership, as did the other employees. The vision must become an internal part of the organization's strategic planning system, goals, and objectives. This will make it very difficult for new visionaries to change the basic functions of the organization.

After the vision has been created, it must be tested. Testing is done with small groups that represent cross sections of the organization. One of the worst mistakes is to have a small group of senior managers create the vision, approve it, spring it on the organization, and find it critically flawed. Testing should ensure that the vision is acceptable and that there is uniform understanding throughout the organization.

The vision is not perfect, however; it is not printed in marble. After all the testing has been done and the vision has been published, someone will find something wrong. The keeper of the vision (someone in the executive's office) should keep a record of all suggestions and, at the annual strategic planning conference, review the vision to ensure that it is still on track and that the organization is on track with the vision statement.

The last area of significance with respect to the care and feeding of a vision is that of spreading the word throughout the organization. Some organizations print fliers, papers, and matchbooks, and publish the vision in the organization's newspaper. Some organizations even print cards for workers to keep in their wallets. It doesn't matter as long as it fits the culture of the organization. More important in the long run, the vision must appear in the daily workings of the organization. When employees use the vision in their daily activities, in communicating with other members of the organization, and in communicating with customers, the vision is the culture of the organization.

Vision, Strategy, and the Tactical System

Vision will provide input to the organization's strategic planning process. Strategy is very similar to vision; both are focused on the direction the organization needs to go. Strategy entails how the organization will reach its goal, and with what resources (employees, funds, and customers). Whereas vision is lofty and general, strategy is much more specific. Closely linked to strategy is the execution component of the strategic planning process—the organization's tactical system. The tactical system is the means and methods the organization will employ to implement its strategy and realize its vision.

Planning, planners, goals, and objectives do not secure the vision of an organization—it is the processes and the people in organizations that ultimately make vision a reality. The strategic planning system recognizes the vital importance of projects and processes in the organization and concentrates its focus in this area. To demonstrate how the strategic planning system works, an annual strategic planning cycle is developed. But before we review the system, it is important to understand some new terms associated with this total quality planning system:

Strategic planning system (SPS)—The SPS is an all-inclusive system that contains the organization's vision, strategic objectives, and tactical planning process.

Senior executive team (SET)—The SET is made up of as many members as the senior executive may choose. It is usually the board of directors and the president.

Strategy formulation team (SFT)—The SFT is composed of those members of the executive's senior staff who are charged with the long-term planning and well-being of the organization. These individuals, who come from all levels of the organization, have earned this special status by understanding the organization, its culture, and its customers. The SFT is a small group of individuals who possess skills and traits that reflect the purpose of the organization. Their function is to set the general course of the organization and transmit it to the tactical formulation team. They also approve the strategic budget.

Tactical planning process (TPP)—The TPP is the execution element of the organization. It is responsible for development of annual planning goals, objectives, program planning analysis, and the budget required to accomplish the strategic statement.

Tactical formulation team (TFT)—The TFT is composed of the senior functional directors of the organization. All disciplines are represented. The group is led by the vice president, vice-commander, or whoever is second in command of the organization. The TFT develops a plan, based on the SFT's directions, to review the inputs from functional organizations and develop the tactical program package. This package contains the operating budget, the investment budget, and the organization's goals and objectives, all of which are developed from input by lower-level organiza-

tions. When the TFT approves the tactical formulation package, it becomes the strategy statement. With SFT's approval, it becomes the organization's operational authority for the coming year.

Strategy statement—The strategy statement is the annual plan approved by the SFT. It contains the approved strategy for the coming year, the goals and objectives that support the strategy, and the budget required. It is the operational authority for the coming year's activity.

The strategic planning time line is portrayed in figure 24. Strategic planning starts with the senior executive's assessment of the organization and its external environment. This strategy assessment is released to the TFT. The TFT distributes the strategy assessment to all areas in which goals, objectives, and budgets are developed.

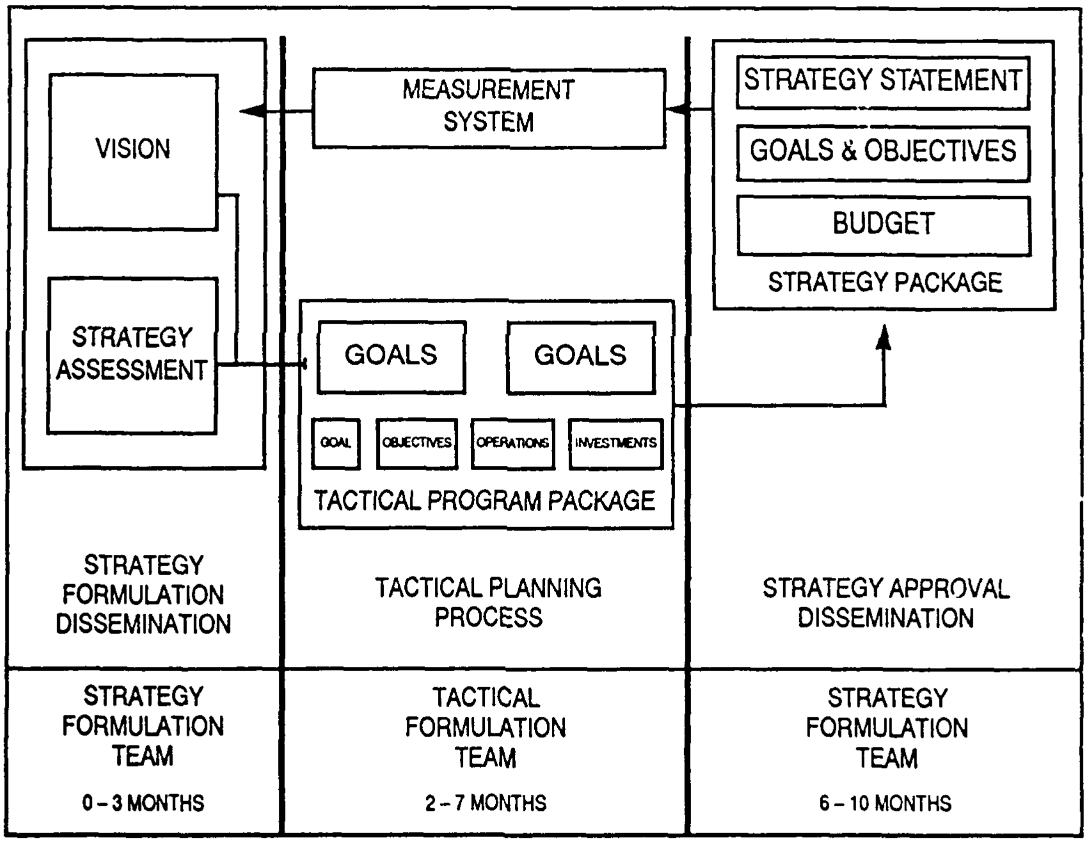


Figure 24. Strategic Planning Model

The TFT consolidates all inputs and develops the tactical program package. The tactical program package contains a detailed breakdown of the goals, objectives, and budget required to meet the strategy established by the SFT. The final package is presented for approval to the SFT.

The SFT receives the tactical program package and acts on it. When the package is approved, it becomes the strategy package. The strategy pack-

age contains all goals and objectives as well as the budget required to accomplish the desired results. The strategy package is then entered into the organization's measurement system. The measurement system provides products to all levels of the organization for assistance in attaining its goals and objectives. Additionally, measurements are provided back to the SFT for developing the next year's strategy assessment.

Table 8 represents a typical cycle in the strategic planning system. The entire process was designed to take less than one year and to allow managers to plan for the next fiscal year.

Table 8

Strategic Planning System Annual Cycle

1. VISION CREATION/REVALIDATION — 0–1 Month

—If there is no vision at this time, now is the time to develop one. Follow the previously listed recommendations for developing a vision.

—For existing visions, this is the time to look back over the last year and determine whether the vision remains current with the internal and external environment. Make changes as needed.

—Publish the vision along with specific direction to the strategy formulation team.

—The senior executive team lists areas where the organization needs to concentrate its efforts. This list may contain areas where improvement was lacking the previous year or directions that senior leaders want the organization to move toward.

2. STRATEGY FORMULATION — 1 Month

—*The strategy formulation team* develops an organizationwide strategy that addresses areas that senior leaders wish to improve or move into.

—Broad strategies are developed for each functional area and associated budget estimate.

—Strategy assessment, along with updated vision, is released to functional areas.

3. STRATEGY DISSEMINATION — 1–3 Months

—Functional areas develop goals and objectives, and a budget, that are consistent with the organization's vision.

—Functional areas propose modifications and new strategies.

—Costs of operations are developed at the functional areas that support the objectives.

—Each functional area submits goals and objectives, and a budget, for the coming year (to the tactical formulation team).

4. TACTICAL FORMULATION — 3–6 Months

—Goals, objectives, and budget requests are received from functional areas.

—Goals and objectives are compared to company strategy.

—Changes are made where needed—in strategy or goals and objectives.

—The annual budget is developed, through functional goals and objectives, to support the company's strategy.

5. TACTICAL PROGRAMMING — 6–8 Months

—Strategic goals and objectives are approved for the next business year and are included in the tactical programming package.

—Operating and investment budgets are approved for the next business year and are included in the tactical programming package.

—Tactical programming package is submitted to the strategy formulation team (SFT) for final approval.

6. STRATEGIC PLANNING APPROVAL — 8–10 Months

—SFT approves/disapproves goals/objectives and budget associated with each functional area.

—SFT issues the organization's strategy statement.

7. DISSEMINATION OF ANNUAL STRATEGY STATEMENT — 10 Months

—Strategy, goals, objectives, and budget authority are released to responsible functions.

—Measurement systems are put in place to assess "budget to goals" and "budget to objectives" accomplishment.

The purpose of the strategic planning process is to tie the vision developed at the senior level of the organization to the goals and objectives developed at the execution levels of the organization, and to the means of accomplishing them—the budget. The single most common complaint about management by objectives (MBO) was that management forced the goals and objectives on employees without giving them the means to accomplish these goals and objectives.[1]

> Difficult as it may seem, it is not an impossible task. For this approach to be feasible, however, budgets must start from a strategy with a specific plan of competitive action translated into sequence and timing of commitment of resources. With a strategy base the overall budget becomes an investment analysis. Cost effectiveness becomes meaningful. Budgets based on strategy demand far more than cost control. They also specify what the money buys, and when. Therefore they can be investment analyzed.[2]

The SPS ties the goals of the organization to a budget. This is covered in chapter 12 under the tactical planning system.

Strategic requirements and the use of mission operation capabilities and quality function deployment were discussed in chapter 5. QFD can be used as the mechanical vehicle to develop and document strategic vision and tactical execution. It is sort of a business plan—the senior planners of the organization document the WHATs and the tactical execution element develops the HOWs. Carried through an iterative process, each level of planning is developed by a different level or process team in the organization: engineering, business operations, manufacturing, and so on—all tied to the original strategic vision.

Notes

1. W. E. Deming, *Quality, Productivity, and Competitive Position* (Cambridge, Mass.: Massachusetts Institute of Technology, Center for Advanced Engineering Study, 1982), 40.
2. Bruce D. Henderson, *The Logic of Business Strategy* (Cambridge, Mass.: Ballinger, 1984), as seen in James T. Ziegenfuss, Jr., *Designing Organizational Futures: A Systems Approach to Strategic Planning with Cases for Public and Non-Profit Organizations* (Springfield, Ill.: C. C. Thomas, 1989), 133–35.

Chapter 7

Mission Analysis Improvement Cycle

If you don't know where you are going, any road will take you there.

—Lewis Carroll, *Alice in Wonderland*

Organizations have just as much trouble as Alice in figuring out what road to take—and for the same reason. To improve an organization, its members must know where they have been, where they are, and where they are going. Otherwise, like Alice, they may end up somewhere they had not planned on. A process called mission analysis improvement cycle (MAIC) can be helpful in determining direction.

MAIC is a nine-step process that enables organization members to better understand their purpose, their internal and external customers, and their suppliers. MAIC assists in the establishment of a mission statement, a requirements log, a measurement system, and a statement that commits all members to excellence.

The nine steps of MAIC are discussed below. Examples are given for private company and government agency settings.

Step 1—*Identify Your Function*

First, figure out the purpose of the organization. What is it in business for? How does each unit support the organization? How do the workers support their units? Focus first on products and then on customers.

Example 1 (private company).

"We are the QuikMop Janitorial Company. Our function is to clean the offices of Air Acquisition Group." Sounds a little humdrum, doesn't it? With this kind of mission statement, it would be very difficult to inspire workers to do their best. Try this instead: "We are QuikMop Janitorial Company. We provide the best janitorial service possible to our valuable customers, with the finest employees available. We value our customers, our employees, and our good name."

Example 2 (government organization).

"We are the Comptroller Division, Air Acquisition Group. We provide cost analysis to the director and to divisions within the group." So? Why is that important? Try this: "We are the Comptroller Division. The group director depends on our timely and

accurate analysis and cost products to determine the health of many programs." (Record it under the "Mission Statement" on the MAIC form [fig. 25].)

MAIC

MISSION ANALYSIS IMPROVEMENT CYCLE

MISSION STATEMENT ______

UNIQUE QUALITIES ______

CUSTOMER(S) ______

SUPPLIERS ______

WE SUPPLY ______

REQUIREMENTS DOCUMENT

OURS ______	INTERNAL CUSTOMER
OURS ______	EXTERNAL CUSTOMER
OURS ______	SUPPLIERS ______

SIDE 1

PROCESS CHECK SHEETS COMPLETED AND ATTACHED

RESOURCE LIST COMPLETED AND ATTACHED

PRODUCTS ______

SERVICE ______

WE SUPPLY ______

MEASUREMENT(S) REQUIRED ______

ESTABLISH COMMITMENT TO EXCELLENCE

COORDINATED DRAFT ______
CUSTOMER ☐ SUPPLIER ☐ INTERNAL ☐

CTE DAY ESTABLISHED ☐ WHEN ______
CTE REVALIDATION DATE (+ 11 MONTHS) ______

LIST OF ATTACHMENTS

FLOWCHARTS
MEASUREMENTS
RESOURCE LIST
REQUIREMENTS DOC

SIDE 2

Figure 25. MAIC Form

Step 2—*Determine Why the Organization Exists or Is Unique*

List those areas that allow it to stand out above and beyond others in the field. Why are workers doing their present work? How did they get their jobs? Who do they work for? What can the organization's customers not do if it fails to do its job? What does it provide them that no one else can? If this organization does not provide it, what will they do?

Example 1.

We exist because no one else can provide the low cost, the high quality, the flexibility, or the responsiveness we provide.

Example 2.

We exist because our customers need cost input from the Comptroller Division to support their analysis of program stability. Without our accurate information, severe loss of funds and/or time would result and our customers would lose credibility with their customers. (Document your uniqueness in the "Unique Qualities" section.)

Step 3—*Identify Customers and Suppliers*

Identify the organization's customers, both internal and external, and its suppliers. Customers are those people whom the organization provides with products or services. Also, organizations that are provided with technical direction in an oversight or corollary function are considered customers. Reports, audits, and inspections are services provided to customers. The focus of the activity may be one group while the customer is someone entirely different. Take for example the inspector general (IG). The IG's focus is on the individuals inspected and serviced, but the customer is the senior executive officer. In another example, Air University (AU) focuses on students but AU's customer is the United States Air Force, which determined that education for its human resources is needed. In those cases where the organization provides by-products to someone other than its prime customer, it should document that interface. The documentation should include everyone interfaced with, and why, as well as what was provided.

Example 1.

QuikMop Janitorial Company (Air Acquisition Group Team)

Customer(s):	Air Acquisition Group
Internal Customer:	Director of Operations (We provide extra manpower when other teams are short.)
Suppliers:	AB Janitorial Supply Company
We supply to:	Joe the Ragman (We supply used rags to JR.)

Example 2.

Air Acquisition Group (Comptroller Division)

External Customer(s):	Programs Division
Internal Customer(s):	Comptroller Division cost analysts
We supply to:	All divisions (We provide guidance and direction on the formats for cost accounting to all divisions.)
Suppliers:	Computer Services (CS)(provides us data processing services.)

(Document these entries in the "Customers and Suppliers" section.)

Step 4—*Identification of the Requirements*

Before an organization can expect to satisfy all its customers' needs, it must identify and understand their requirements. Likewise, for its requirements to be fully satisfied and for it to receive products that support its needs, it must document its requirements with its suppliers. If the organization doesn't know those requirements or if it cannot measure conformance to them, it will have a difficult time meeting them.

The organization must establish or acknowledge three sets of requirements: (1) *external customers' requirements* placed on it and its requirements on them; (2) the *requirements of its internal customers* and its requirements on them; and (3) the *requirements it places on its suppliers* and the ones they place on it.

One of the critical areas left out in most discussions on requirements is the producer's requirements on the customer and the supplier's requirements on the producer. These requirements represent half of the requirements that go into a quality process, and they are as important as the product's requirements. All those customers that the organization provides some by-product to on a regular basis should be included in requirements processing.

Example 1.

Producer	*External Customer*
Identify special cleaning requirements no later than four hours before start of shift.	Clean facility in accordance with statement of work contained in contract DC RC-3415.
Producer	*Internal Customer*
Notify the shift foreman of any need for additional workers.	Provide trained employees, when requested, to support other contract efforts.
Producer	*Supplier*
Provide supplies, within 16 hours of requisition, to location specified.	Provide list of urgently required supplies to priority dispatcher. All other supplies can be ordered through sales dispatcher.

Example 2.

Producer	*External Customer*
Provide request for analysis on Form 3192 in triplicate to the chief, analysis division, no later than 72 hours before analysis is required.	Provide analysis of programs in accordance with our letter no. JAN87-102-5.
Producer	*Internal Customer*
Provide continuous data processing support during times of critical analysis.	Identify urgent data processing requirements prior to the beginning of each shift.
Producer	*Supplier*
Provide cost accounting sheets to the analysis division no later than three working days after closeout.	Provide changes in direction prior to the beginning of an accounting period.

(Record this information under "Requirements" on the MAIC form.)

Step 5—*Identify Processes and Resources*

Identify the processes and resources used to satisfy each of the requirements identified in step 4. Identify the sources of these resources by organization and by responsible individual. Also identify all processes by organization or unit and by responsible individual. Identify the product of the process and its destination.

Processes—Establish a flowchart for each discrete process (document, component, decision path, or assembly [fig. 26]). Follow the conventions described in chapter 11 to properly chart the process. As resources enter the process chart, their origin and place of entry are noted. A procedures check sheet (fig. 27) can be used to simplify the process and develop the flowchart.

Resources—Establish a list of all resources required to satisfy all customers' requirements. Cross-check this list with a listing of suppliers. All resources should be identified. When this process has been completed, check the appropriate boxes on the MAIC form. Then attach the procedures check sheets (fig. 27).

Example 1. Resource List

Resource	*Source*	*Quantity/ Frequency*	*Req Doc Approval*	*Measurement Frequency*	*Owner Inter*	*Owner Exter*
Mops	ABC	2/wk	1Jan89	Preferred supplier	Sam	Bill
Soap	ABC	18Gal/wk	1Jan89	No inspection-required	Sam	Bill
Buffers	Clean Eq Inc.	As required	Pending SPC audit	Pending SPC audit	Joe	Jane

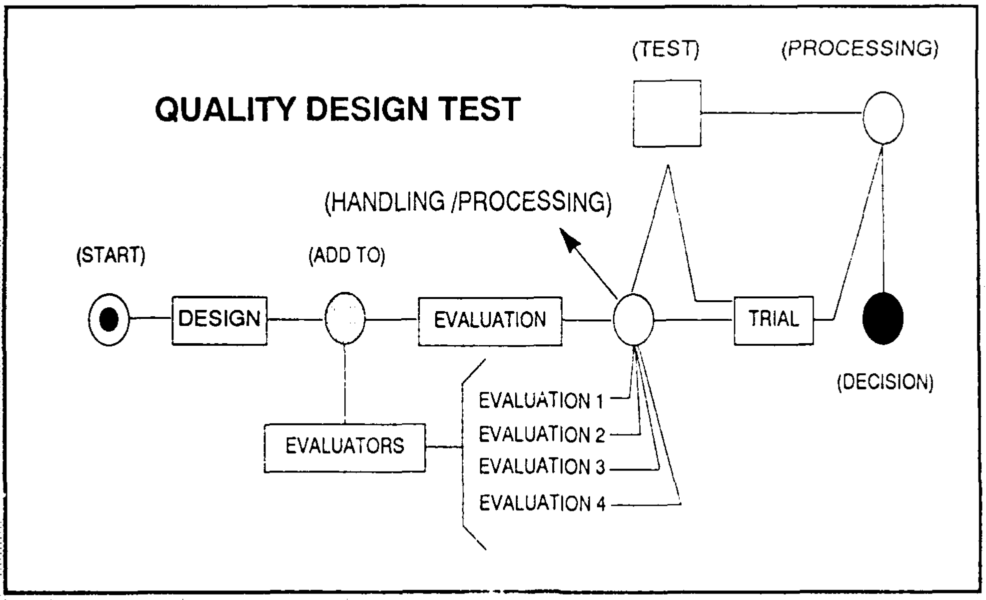


Figure 26. Gilbreth Flowchart

Example 2. Resource List

Resource	*Source*	*Quantity/ Frequency*	*Req Doc Approval*	*Measurement Frequency*	*Owner Inter*	*Owner Exter*
Data Processing	ACC	Nightly	29Feb88	Daily until certification	MSgt Bute	Sgt Bit
Computer Terminal	SIC	As required	1Mar89	As required	Mr Stone	Mr Joms
Software	SIC	As required	1Mar89	As required	Mr Stone	Ms Apps

Step 6—*Identify Products and Services*

Identify the products or services that satisfy the requirements identified in step 4. These products and services are the purpose of the organization's existence and can fully satisfy its needs only if they meet its customers' expectations. An understanding and an appreciation of those expectations are critical to ensuring that the organization provides an excellent product or service. These expectations, the environment the product is intended for, and the customers' views of quality must be incorporated in the delivered item.

PROCEDURES CHECK SHEET

CHART NUMBER

PROCESS ______________ DATE __________

PREPARED BY ______________________________

PAGE ________ OF ________ PAGES

DECISION								
ADD TO								
HANDLING								
INSPECTION								
STORE, DELAY, DISPOSE								

EFFECT	CODE	DESCRIPTION	QUALITY	QUANTITY	TIME

Source: Adapted from Martin Marietta's procedure data chart.

Figure 27. Procedures Check Sheet

It is important to identify the products or services provided the organization's internal customers as well. In most cases, these products or services are components used to support an end product that someone else delivers to an external customer. The organization must work with its internal customers to get a better understanding of how its product fits into the process.

The last items to identify are the by-products the organization provides. These too are important in the overall total quality organization, and they must be identified if the organization is to maintain continuous control over the processes that are involved. (Document these products and services on the MAIC form.)

Example 1. Products and Services

QuikMop Janitorial Company

PRODUCT: We provide trained personnel and high-quality products to customers who require a clean office environment.

SERVICES: We provide trained personnel to our internal customers who, for one reason or another, need temporary assistance to perform their functions and maintain the good name of QuikMop Janitorial Company.

SUPPLY: We supply used rags to Joe the Ragman. He pays us for those rags, which enables us to be more competitive in the marketplace.

Example 2. Products and Services

Air Acquisition Group Comptroller Division

PRODUCT: We provide thorough and totally accurate cost analysis to the Programs Division for critical, time-sensitive decisions on program stability.

SERVICE: We provide cost-accounting services to the Air Acquisition Group in support of their varied functions.

SUPPLY: We supply direction and guidance on cost-accounting standards throughout the group, and we audit for compliance.

Step 7—*Identify Inspections for Measurement System*

If improvement is to occur, a system must be established to monitor progress or regression. Many managers feel that the only area where measurement can be applied is in production, but this is far from the truth; every input and every output provide probable measurement points. This includes finance, personnel, engineering, and other services.

Identify the inspections that must be made of the processes to ensure continuous improvement. These inspections should reflect the requirements identified in step 4, along with the customers' expectations of quality. Inspections identified in this step should be included in the measurement system.

If the organization does not have a measurement system, refer to chapter 11 to establish one. In the services area, there are two useful measurement processes that can be initiated at step 7: mean-time-to-error and target tightening.[1]

Mean-Time-to-Error

In this process, a system is established to measure the time between errors. Start by measuring the number of errors per day. As that number becomes meaningless (fewer than one per day), move to measuring the number of errors per week, then per month, and so on. This approach makes the data easy to record, and it can be applied to any activity in an organization.

Target Tightening

In this process, two sets of targets are established: a quality-cost target set by customer requirements at the beginning of the project and a challenge target established to improve through striving for excellence. When the challenge target has been met (e.g., an average of fewer than one "reject" per month for six months), it is re-set. As challenges are met, both the organization and the customer benefit.

When this step has been completed, attach the listing of inspections that need to be performed (by the measurement system) to the MAIC form, along with the procedures check sheet and resource listing.

Step 8—*Establish Commitment to Excellence*

Now that the first seven steps have been finished, the organization has the information to establish a long-term, continuing commitment to excellence. This is done with the assistance of employees, suppliers, and internal and external customers.

Using the information on the MAIC form and its attachments, construct a "commitment to excellence" statement similar to the example shown in figure 28. Work with employees, customers, and suppliers to get their agreement. Once everyone has agreed to the statement, have it professionally printed. Have a special ceremony—bring together all the signatories, using as much fanfare as possible.

Annually revalidate the commitment to excellence and modify as needed. Publicly announce the performance levels of all concerned: the organization, its suppliers, and its customers. Then reestablish the commitment. Display the commitment to excellence for all—especially management—to see and remember.

COMMITMENT TO EXCELLENCE
OF THE
AIR ACQUISITION GROUP
COMPTROLLER DIVISION

FUNCTION We are the Comptroller Division, Air Acquisition Group. We provide cost analysis, guidance, direction, and inspection services.

PURPOSE We exist because our customers need accurate cost analysis from the Comptroller Division to support their analysis of program viability and warning. Without our accurate information, severe loss of funds and/or time would be lost and our customers would lose credibility with their customers.

CUSTOMER(S) Our customers, both external and internal, are the sole purpose of our existence. If we do not meet their expectations, the Comptroller Division's leadership has failed to provide the employees what was needed to do their jobs. Our customers are identified below:

EXTERNAL CUSTOMER(S) Air Acquisition Group's Programs Division
INTERNAL CUSTOMER(S) All Comptroller Division's cost analysts
WE SUPPLY Guidance and direction on formats and cost accounting standards. We also inspect for compliance.
OUR SUPPLIER(S) Computer Services Division provides high quality computer support as specified in our Letter of Agreement, AC-LOA-3.

All divisions that provide program cost information as specified in our Letter of Agreement, AC-LOA-4.

REQUIREMENT(S)

EXTERNAL CUSTOMER

Our customer requirements are contained in Specification 123-654, dated 1 January 1989. The requirements contained in this specification are considered the minimum acceptable. As an excellent organization we are challenged to provide better than the customer expects. Our requirements for the customer are contained in AC-LOA-1.

INTERNAL CUSTOMER

Internal customer requirements are contained in requirement sheets by the owner of each process.

SUPPLIERS

Our requirements for suppliers are contained in Contract 123-987-1.

Their requirements are also contained in Contract 123-987-1.

PRODUCTS We provide thorough and totally accurate cost analysis for the Programs Division to make critical, time-sensitive decisions on program viability.

SERVICE We provide cost accounting services to the Air Acquisition Group in support of their varied functions.

WE SUPPLY We supply direction and guidance on cost accounting standards throughout the group, in addition to audits for compliance.

MEASUREMENT(S) We measure for requirements compliance on a continuous basis and pass the results to the owner of the process so that continuous improvement is ensured.

COMMITMENT

As a team, we are dedicated to the excellence of our products, processes, and requirements. We will not accept any product, process, or requirement that does not totally meet our expectations. We will ensure excellence through continuous improvement.

Comptroller, AAG	Director, Programs	
Deputy Comptroller, AAG (Rep for internal customers)	Supplier	Effective date

Figure 28. Sample Commitment to Excellence

Step 9—*Document and Educate*

Put the MAIC form, the process flowcharts, the resource listing, and the required measurements to use. The MAIC becomes the basis for training and educating employees, a means to expand the organization's business base, and a compendium of information. This information should be readily available in any operation, but it is seldom found in one place within traditional operations. In MAIC, one set of documents provides all the information necessary to answer routine questions.

As the basis of a training plan, MAIC provides the information that supervisors and employees need in order to do their tasks. As stated earlier, 80 percent of most organizations' workers do not know their jobs and are afraid to ask. Use MAIC during interviews with new employees, or during annual counseling sessions, to discuss process ownership, measurements, and continuous improvement practices. MAIC will provide the "big picture" for the employee—something previously reserved for management.

The last task is to clean up MAIC and its attachments and distribute them to everyone who owns a process or supervises someone who owns a process. Provide copies to training managers and direct them to ensure that training is consistent with the functions performed. Provide copies to the marketing or sales force. They need to understand internal and external relationships, and to learn where future business could be developed. Finally, keep a copy, read it, and make it happen.

MAIC receives input from the strategic vision element, the requirements element, suppliers, and both external and internal customers. It provides output to the organization, suppliers, internal and external customers, the continuous improvement process element and the measurement system, and the direction/feedback element.

MAIC can be applied at the macro level—broad and general—or at the micro level by individuals responsible for a single process (one supplier and one customer). If properly done and religiously applied, it will improve the organization's awareness of critical information that is vital to its success.

Notes

1. Both of these concepts are discussed in H. James Harrington, *Excellence—The IBM Way* (Milwaukee, Wis.: ASQC Quality Press, 1988), 19, 20. Although I have modified the IBM application to the MAIC process, a review of the IBM approach will be valuable to the reader.

Chapter 8

The Organization

When nothing seems to help, I go and look at the stonecutter hammering away at his rock perhaps a hundred times without as much as a crack showing in it.

Yet at the hundred and first blow it will split in two, and I know it was not that blow that did it—but all that has gone before.

—Jacob Riis

Three elements affect a total quality organization more than anything else. The people who work in the organization comprise the first element. The organization is directly affected by employee dedication, knowledge, and training. The second element is the management structure. The manner in which decisions are made directly affects the productivity of the organization. Finally, the organizational principles that guide activities comprise the third element. The way the organization deals with its employees, customers, suppliers, shareholders, and conflicts is also an important ingredient in a total quality organization. People, management structure, and principles make the difference!

People

Through the managers and leaders they place in positions of power, organizations set the tone for individuals in the work environment. The selection of leaders and managers is based on the organization's assumptions about people, their work ethics, and their long-term value to the organization. Total quality organizations believe that people must be totally involved in all processes of the organization if the organization is going to achieve long-term success. Total quality organizations believe that their people are competent, and they base policies and practices on the knowledge that people will do what is best for the organization because it is also best for the individual.

The total quality organization believes that productivity is achieved through competency. The total quality organization believes that people are competent and productive by nature. At the same time, the total quality organization believes that competency is improved through training—it increases the individual's competency, productivity, and self-worth. Training, which should be continual, is considered the strongest motiva or a total

quality organization can provide its people. To stimulate the competency cycle, the total quality organization develops an environment supportive of competency, creativity, and commitment to excellence.

A total quality organization recognizes three essential components of competency: commitment by the organization to the individual; creativity in a supportive environment; and trust by the individual that successes will be rewarded and isolated failures will not be punished. Commitment, creativity, and trust form the basis for the total quality organization's culture. Managers and leaders recognize the importance of these elements. Through a team structure, all employees participate in the management of the organization. In a participative management system, the collective ability of all employees is recognized, and all of them take part in decisions that affect the processes they have responsibility for. In a total quality organization, participation in the decision-making process is required of all employees because the focus is on long-term growth and quality. Employees are encouraged to collaborate with each other to increase productivity. When multifunctional teams collaborate, both quality and productivity increase because the team members do what needs to be done when it needs to be done. The cooperation of employees across functional organizational lines in the decision-making and planning processes demonstrates the organization's belief in the competency of the individual. These individuals are in the best position to influence and control their work; and in the proper environment, these employees will consistently do their best. Productivity is at its best in a total quality organization.

The total quality leader (TQL) believes that problems should be faced squarely and constructively. Conflict is inevitable, and the TQL encourages its expression for a better understanding of the issues. The TQL believes that when the issues are understood by all, agreement will be reached and the total quality organization will consistently produce superior services or products. But complete consensus may not always be achieved. In these cases, the TQL will try different approaches to gain total group consensus.

The TQL approaches conflict as ignorance of all the facts; since someone is unaware of information that someone else possesses, the sharing of this information is part of the process of making quality decisions. Interaction between positions offers the opportunity for all to get their concerns on the table and determine together which way the decision should go. This process produces decisions that are more acceptable to the team members than decisions forced upon them.[1]

Conflict between teams is approached in the same way as intrateam conflict. The TQL encourages a free dialogue, so that both teams will better understand each other's problems, and seeks multiteam solutions. Inter-team decisions mutually agreed to will produce superior resolutions that all teams are better able to support.

A total quality organization does not come easy. Total quality management isn't even taught in business schools. The principles of total quality management, participative management, and organizing through teams

have not been combined into a concerted, well-defined leadership philosophy until now. The classical American leader believes that high-quality production and concern for the individual worker are mutually exclusive: To achieve one, you must compromise the other. This is far from the truth, however!

The environment in a total quality organization is as important as the people in that environment. Total quality organizations develop a structure that promotes an atmosphere of trust, eliminates fear, and provides the tools to ensure that all employees can do what is expected of them.

Management Structure

A total quality organization is arranged so that teamwork is essential and teams act as independent operating centers of excellence. Unit-centered, independent operating teams can be compared to the individual operating units of multidivisional organizations. Each division attempts to satisfy its customers with its own products and is encouraged to maximize customer satisfaction and increase profits. Some of these profits are used for the central funding of services like research and development, accounting, and legal work. Central funding is the area where the divisions come together to operate as teams in sharing common goods and services.

If Division A uses more than its share of the available research and development, other divisions will have less service available to them. Profits may increase at Division A because of its selfish use of a service while profits at the other divisions decrease. But in the long run, Division A will be forced to pay more "dues" to the corporate organization.

If self-restraint does not keep Division A from overusing central resources, the collective division leaders will force it to work with the other divisions. The alternative to this arrangement is a headquarters (organization above individual divisions) that gets larger and more powerful because it is working for the senior officer of the headquarters and not providing services to the divisions. Division leaders recognize that if they don't operate as a team, the headquarters will grow as their organizations shrink.

Total quality organizations can use an arrangement similar to multidivisional organizations. Central leadership is provided from an executive group comprised of the senior executive officer, a deputy, and three to seven other senior officers, each of whom represents a special function. The executive group meets frequently but not necessarily for long periods of time. Members discuss the most pressing issues of the day and develop long-term strategy for the organization, working with five special function teams: statistical process team (SPT), quality personnel team (QPT), quality resources team (QRT), customer research and development team (CR&DT), and strategy formulation team (SFT) (fig. 29).

Strategic orientation is interorganizational and external; tactical orientation is intraorganizational and internal. Strategic orientation drives the

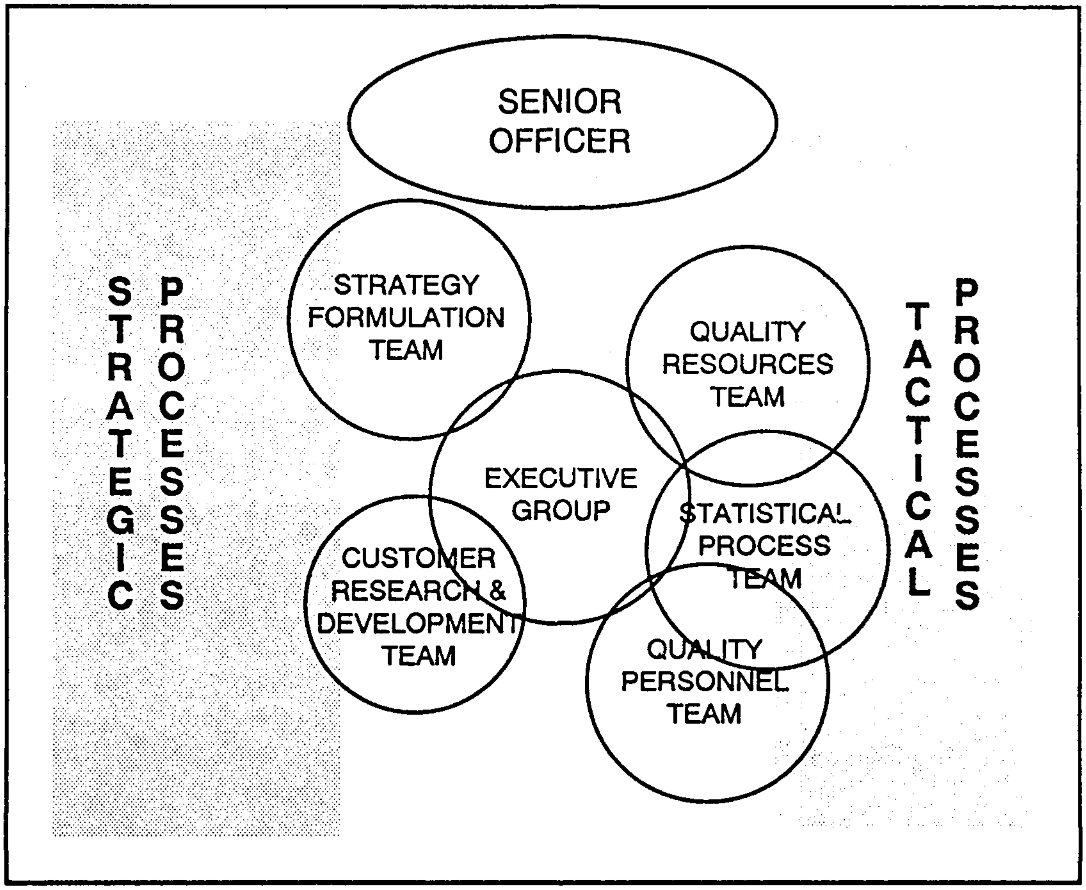


Figure 29. Desegregated Management Structure

vision; tactical orientation is driven by the vision. Strategic orientation originates from the external environment and is brought into the organization; tactical orientation originates within the organization and is represented in the external environment through products and services.

Each special function team operates quasi-independently of the executive group. Each team knows its own purpose, function, and processes and, through linkage to the executive group, is cognizant of other activities across the organization. When the QRT, QPT, and SPT meet together, they become the tactical formulation team (TFT), which is responsible for developing, reviewing, and managing the organization's strategy package.

The quality resource team is responsible for policy development, resource guidance, program development, budget formulation, and long-range goals and objectives. The QRT reviews inputs from the process group to determine where and when action should be taken.

The statistical processes team works with the resources team and personnel team to ensure that all actions recommended or taken are consistent with maintaining efficiency. The SPT has the primary respon-

sibility for administering and executing the organization's measurement system.

The SPT is responsible for the organization's awards program, and for establishing policy and guidance for the personnel appraisal system (which is administered through the QPT). This latter point may seem a little unusual, but personnel appraisals and rewards are also a form of process control. It is important in a total quality organization that variability in human resources be controlled as other process resources are controlled. It would be counterproductive to have one division rewarding employees for superior performance if that performance was detrimental to other divisions. The QRT maintains the quality of performance appraisals and rewards across the organization, keeping the focus on quality in every division.

The customer research and development team is responsible for looking at the long-term needs and wants of the organization's customers. Composed of senior leaders throughout the organization, it also includes a select group of high-value customers when possible. The CR&DT's prime focus is to plan for continuous improvements beyond the incremental improvements that statistical process control accomplishes.

The strategy formulation team is made up of the senior directors of each major functional group in the organization. Responsible for the long-term perspective of the organization, the SFT recommends long-term policies and programs the organization should begin to invest in for growth and improvement. It also establishes the organization's principles and mission statement. It meets at least annually, issues the strategy assessment, and approves the strategy package. At other times throughout the year, this group meets away from the day-to-day activities of the office to set the course for the organization in the coming years. The SFT will also take on a particular major problem confronting the organization and work it until consensus has been achieved.

The purpose of this desegregated management structure is to force groups and organizations to work together. Under the desegregated management structure, it is harder for individual units to pursue their own goals and objectives, build up barriers, and establish self-fulfilling prophecies at the expense of other work units. Through multiple integration of groups at senior levels, conflicts and problems can be resolved if knowledge and resources are available.

The formality of the senior teams and groups depends on the size of the organization and the styles of the senior leaders. The less formal these groups are, the better they will integrate with other teams and groups. The desegregated management structure is not intended to be placed on top of existing structure—it is intended to replace it. There will be seven senior-level forums. The executive group meets daily, SFT meets at least twice a year, TFT meets monthly, and the others meet as needed. Compared to the industry average, this represents a significant reduction.

Meeting time will be reduced if there is a strong team structure below the senior level that can integrate problems across the organization. The process improvement team (PIT) is comprised of members who are not always from the same natural work group but who have been charged with process review, correction, and improvement. PITs work directly for the TFT, regardless of their permanent location. Created for specific problems, PITs generally are not full-time positions; when the problem has been corrected or the process improved, its members return to their original organizational position. PITs are created and dissolved by the TFT.

Process action teams (PAT), on the other hand, are created at any level and are comprised of individuals who have ownership of a process. They are the natural work group of individuals who have corollary responsibilities. A good example of a PAT would be the team that repairs automobiles. In this example the PAT is composed of the mechanic who does the hands-on work, the technician who receives the automobile from the customer, the supply clerk who stocks parts for all vehicles, and the quality auditor. These individuals might participate on several teams. Ownership of processes by even the more remote employees increases productivity and quality.

PATs resolve problems that they have the authority to solve and if the required corrective action is available within the work environment. When corrective action is outside the work environment, or when changes to a process will affect another work group and corrective action cannot be agreed to between PATs, the issue is elevated to the TFT for resolution. The goal of this process is collaboration between multifunctional groups. However, when resolution does not happen, the TFT makes the final decision, using information presented from both PATs. In some cases, the TFT would form a PIT with select members from each PAT and charter its objectives and schedule.

A total quality organization understands how to use teams throughout the organization to improve quality. Peter Scholtes has described in detail how an organization can make effective use of teams in his excellent how-to book, *The Team Handbook: How to Use Teams to Improve Quality.*[2] The "bible" for all team leaders and project managers, its approach to team success is capsulated below. Team success is much the same as success in other organized endeavors, and it depends on the same components: an understanding of the mission, knowledge of the requirements, effective communications, and good people. Scholtes has developed the following structured approach for team success.

<u>Set the Stage for Success</u>

1. Select a process, not a system, for the team to work on.
2. Select a process that the team members are interested in.
3. Select improvement, not solution, as team goals.
4. Select a process that is not in transition.

Organize the Team for Success

Establish at least four team divisions.

1. Guidance Team—The guidance team initiates the team, provides its direction and authority, and keeps the rest of the organization from inhibiting the team's activities.
2. Team Leader—The team leader manages all the internal activities of the team and interfaces with external organizations as required.
3. Quality Advisor—The quality advisor is the outside consultant to the group. The advisor possesses advanced training in project management, group process, statistics, and scientific tools.
4. Team Members—The team member is the strength of the team. Team members work directly for the team leader. They have been appointed by the guidance team.

Prepare for Success

When it has been determined that a team needs to be formed to address a particular issue, the initiating leader is responsible for the team's success or failure.

1. Identify team goals.
2. Prepare mission statement.
3. Determine needed resources.
4. Select team leader; review goals, mission, and resources.
5. Select quality advisor; meet with advisor and leader.
6. Select team members.

Establish a Foundation for Success

1. Establish team-building goals. Team members come to the team unsure of at least three things: other team members, decision-making policies of the team, and the rules of engagement. Each of these areas needs to be covered in sufficient depth to ensure that team members can be effective.
    a. Get to know each other.
    b. Establish decision-making rules.
    c. Set ground rules for meetings.
2. Establish education goals. The first meeting should provide an overview of
    a. the quality movement.
    b. teams and teamwork.
    c. processes and variation.
    d. customers and suppliers.
3. Establish a plan for action.
    a. Study the selected process.
    b. Identify team members' responsibilities.
    c. Set guidelines for good meetings.
        (1) Use agendas and stick to them.

(2) Identify one person to keep the meeting focused.
(3) Identify one person to keep minutes.
(4) Review this meeting and plan for the next one.

Taking the time in the beginning to ensure that the team is organized and operating for success will seem like inactivity to some. After all, the team isn't "digging in" and showing active work on the project. But experienced and successful teams have found that the time spent in the beginning will more than pay for itself throughout the team's life cycle.

A total quality organization that employs the desegregated management structure uses multiple teams to remove the barriers that prevent some groups or individuals from having complete access to "sacred" processes. This structure does not come easy—the organization must possess a special character or "organizational culture" that accommodates openness, trust, and a spirit of continuous improvement. And senior leaders must understand the existing culture in their organization before they create a vision of the future organization. The vision is communicated to the organization through the strategy assessment. Senior leaders should also reaffirm the organization's principles. The principles of the organization, the vision of senior leaders, and a dedicated and well-trained work force are what turns dreams into reality and intentions into actions.

Organizational Principles

Organizational principles are intended to work hand-in-hand with organizational culture. They are intended to provide a set of precepts workers can use in their daily activities, managers can use in the administration of their duties, and policymakers can use to ensure that their actions are proper and consistent with the organization's principles. Principles also provide a road map to young leaders, who use the principles as a guide in developing their leadership style.

The following 10 guidelines encompass the principles of a total quality organization. They are intended to provide the broad guidelines a total quality leader may use to document the conduct desired in the organization. Use them, modify them, and make them match the organization. Then live by them!

1. Establish a vision and weave it through every activity in the organization.
   a. Ensure that the vision is understood.
   b. Stress top quality as seen by the customer.
   c. Stress continuous improvement.
2. Establish a strategic planning process that translates the vision into meaningful goals.
   a. Ensure that the goals are achievable.
   b. Identify impediments to progress and eliminate them.

3. Establish a culture philosophy that reflects the high rate of change in a high-performance organization.
    a. Stress continuous improvement.
    b. Stress innovation and flexibility.
4. Organize by empowered teams.
    a. Stress that everyone is important to quality products.
    b. Identify the singular importance of customer satisfaction.
5. Measure everything that is important.
    a. Stress that measurement is the only way anything can be improved.
    b. Stress the importance of measurement at different levels.
    c. Put all processes in statistical control.
    d. Establish processes for benchmarking between organizations.
6. Make all business decisions based on quality first *and* second.
    a. Stress the importance of suppliers providing quality products and stay with quality performers.
    b. Stress the importance of providing quality products to internal customers.
7. Create leaders throughout the organization.
    a. Stress the importance of leadership and action at every level.
    b. Stress the importance of education and failure as learning experiences.
8. Establish ownership of every process within the organization.
    a. Stress the authority and responsibility that go with process ownership.
    b. Establish new roles for middle managers.
9. Establish pride, professionalism, and confidence in all employees.
    a. Eliminate fear between worker and supervisor.
    b. Eliminate barriers between different functions.
    c. Stress teamwork and harmony.
    d. Provide the education and the tools needed to realize the vision.
10. Demand total integrity from every level of the organization.

Notes

1. Jay Hall, *Styles of Teamwork Inventory* (The Woodlands, Tex.: Teleometrics International, Inc., 1989).

2. Peter R. Scholtes, *The Team Handbook: How to Use Teams to Improve Quality* (Madison, Wis.: Joiner Associates, Inc., 1988), 4-2 through 4-42.

Chapter 9

Suppliers

He who has a rule to give his business to the lowest bidder deserves to get rooked.

—W. Edwards Deming

In 1989 the United States Air Force Scientific Advisory Board visited an F-111 wing in Europe to investigate the reliability of fasteners, actuators, tools, and subsystems (F-A-C-T-S). The F-A-C-T-S team found that 25 percent of the US interdiction strike force was out of commission because of a faulty electrical connector used on the aircraft's weapon pylon.[1] This is not an isolated case. Other examples can be found—in DOD and the commercial sector as well. Low reliability and poor overall quality are common among nonglamorous parts and components.

Buying from the Lowest Bidder

Buying from the lowest bidder is standard operating procedure in most organizations, including DOD. In the case of DOD, it is more than a standard procedure—it's law. Dependency on a system that purchases goods and services on the basis of price alone will cost producers and suppliers business in the long term. Let's look at an example of how awarding business on price alone affects both quality of products and livelihood of quality manufacturers. We will stay with the example of the pylon electrical connector used on the F-111.

Three suppliers responded to our fictitious proposal for pylon electrical connectors: ABC Electronic MFG, Yale Electronics Company and Princeton Connector Company. The per-unit prices on their proposals were $100.00, $90.00, and $80.00, respectively. The purchasing agent awarded the contract to Princeton Connector Company since all potential offerers met the terms and conditions of the solicitation. Given the limited information available, the agent had no choice other than to award to the lowest bidder. When information about quality is added, however, the picture changes.

ABC Electronic MFG was educated in the TQM process five years ago and has applied TQM principles throughout all its processes and practices. As a result, ABC's processes produce only one defective unit per million. The true unit price of ABC's electrical connectors can be expressed as the unit cost divided by (1 – the defective rate), or

$$\frac{\$100}{(1 - .000001)} = \$100.00$$

Yale Electronics Company has been considered a very good producer of quality products over the years and has a strong quality department. Yale has steadily maintained a 90 percent effective rate. The true unit price of Yale's electronic connector can be expressed as

$$\frac{\$90}{(1 - .10)} = \$100.00$$

Princeton Connector Company began business just over a year ago. Princeton has no record of its process defective rate, but stipulates that its quality process will meet (MILSTD) 9858 and that its connectors will meet military standard requirements. Princeton's connector rate can be expressed as

$$\frac{\$80}{(1 - X)} = ?$$

With the addition of quality information, the purchasing agent could eliminate Princeton because of its unknown unit price and concentrate on the producers with the same unit price. The proper choice would be ABC because their processes are within control and cost and will not fluctuate throughout the contract.

This exercise demonstrates that buying by price alone will not necessarily yield the lowest price. It also demonstrates that purchasing agents need to be trained to select quality suppliers. The practice of selecting the lowest bidder has a long-term effect of driving quality producers out of the marketplace.[2]

Single-Source Purchasing

Once an organization has accepted quality-based buying, the next major hurdle to overcome is the practice of annual competition and annual contract awards. If buying is based on quality, there is no reason to change suppliers every year. One supplier per item will reduce the number of contract actions required, generate incentive for suppliers to improve products, and reduce the work loads of purchasing agents, freeing them to analyze and evaluate potential new suppliers.

Impact

The true impact of single sourcing is tremendous. One Detroit automotive company estimated that it could go from 4,000 suppliers to 800 if it instituted a single-source policy.[3] If each contract action cost as little as $1,000 for the automotive company, the reduced number of contract actions would amount to an annual savings of $3.2 million. This doesn't include

the savings that would be realized from the supplier not having to prepare proposals for the solicitation. If the supplier's cost to prepare a proposal were the same as the manufacturer's (most suppliers would say it is at least twice the manufacturer's cost), the savings would also be $3.2 million. Thus, by moving to single sourcing, administrative costs would nominally be reduced $6.4 million by this American automaker. Very few business propositions realize such gains.

Firms have found numerous reasons not to pursue single sources for vendor-provided items. One reason, seldom given, is that the purchasing community would lose significant size and power with a move to single sourcing based on quality. Using the example of the automaker above, 3,200 fewer purchasing actions would be required. The reasons usually mentioned for not moving to single sourcing are

> (1) protection against disaster—acts of God, strikes, fires, and explosions; (2) price increases, increases in the vendor's bargaining position, vendor bankruptcy, vendor inventory shortages, vendor failure to meet promised delivery schedule, and vendor downtime; (3) vendor's inability to supply the required volume; and (4) vendor not possessing the technology or patents required.[4]

Items 3 and 4 can be overcome through investigation of the supplier before contract award.

In 1983 L. M. Chicoine, Ford Motor Company's vice president for purchasing and supply, decided to improve Ford's position by moving toward more long-term relationships. With full support from Ford's chief executive officer (CEO), Chicoine directed that his organization move to more long-term contracts. As any good manager would, he began to track the results and discovered that there was little appreciable change after six months. Investigation found the reason: there was a policy within his organization that all contracts over one year long required full justification and approval at two levels above the buyers.[5]

Chicoine found that middle management had failed to provide the incentive that workers needed. As a matter of fact, the policy provided negative motivation. The solution was to establish a new policy: any contract *not* written for longer than one year required full justification and approval at two levels above the buyer. This is an example of the Deming 85/15 rule—where 15 percent of workers' decisions are within their control, 85 percent are under the control of management. The point to this is that when senior managers decide to move to single-source suppliers, they must review their organization's bureaucracy for hidden policy.

Quality Advantages

Reducing the number of suppliers will increase overall quality and reduce the total variability within an organization. As variability decreases around a center point (mean), quality increases and process control increases. To examine the effects of multisourcing, we will look at the quality distributions of three suppliers (fig. 30).

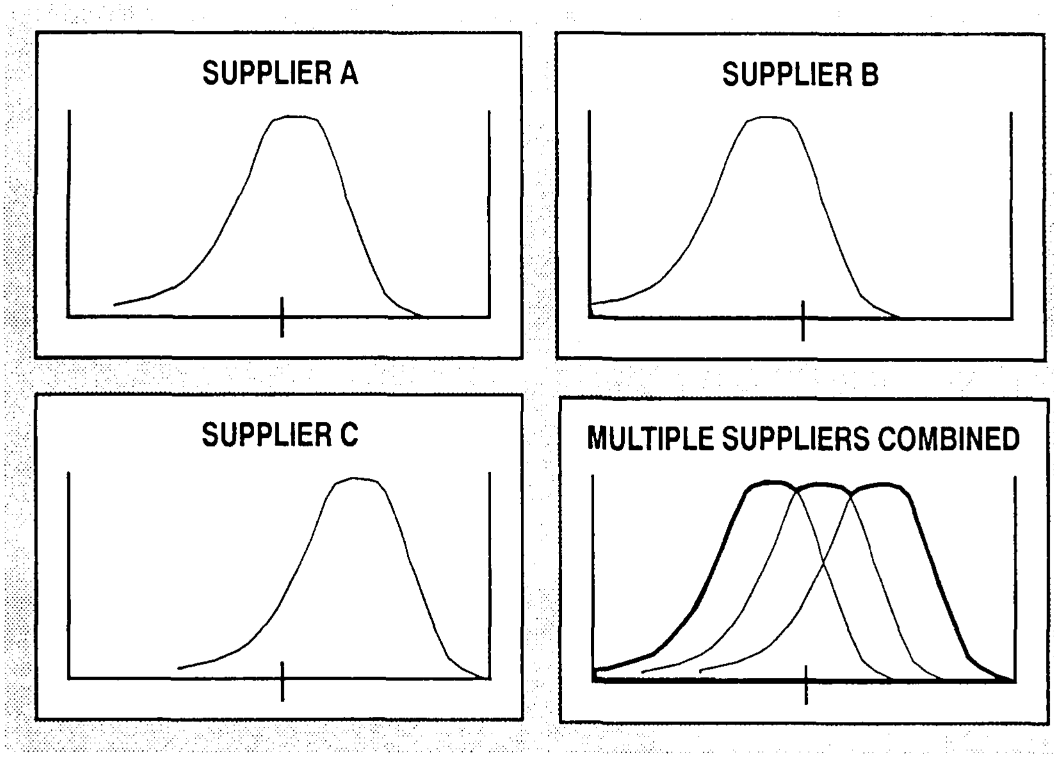


Figure 30. Quality Variability

Reducing the number of suppliers will reduce the cost of maintaining support systems for multiple suppliers. Staying with our example of the American automaker, a reduction of 3,200 suppliers means that in addition to the cost avoidance of $3.2 million for not having to process 3,200 purchase requests, the company avoided the following costs:

1. travel cost to multiple vendors,
2. loss of volume discounts,
3. increased setup cost,
4. increased investment in capital equipment and/or test equipment,
5. increased inventory cost due to carrying multiple vendors items and their spare parts,
6. increased training cost of maintenance personnel to work with multiple vendors' materials, and
7. increased tooling requirements.[6]

Multiple sources precipitate increased variability and poor quality, and multiple sources cost more than single sources. Fear of relying on single sources is the only thing to stop organizations from moving to a single-source vendor environment. This fear can be arrested through a thorough evaluation of potential suppliers. Organizations should establish a set of criteria for vendor selection and make it clear to existing vendors that the

organization will evaluate their proposals based on these criteria. The organization should further state that the vendors selected will receive long-term contracts and be considered principal suppliers, a status which affords them first opportunity to qualify for any new business.

The criteria established to evaluate prospective vendors should not be much different from those used to evaluate total quality within the organization. Some examples specifically suited to vendors are listed below.

1. Our vendors place high importance on quality through continuous process improvement.
2. Our vendors are organized so that quality problems can be worked at every level.
3. Our vendors follow the principles of total quality management.
4. Our vendors are financially sound.
5. Our vendors are located in areas that are not known for hurricanes, tornadoes, or other acts of God.
6. Our vendors are located in areas that are not known for political problems.
7. Our vendors have good relationships with their employees and with organized labor.
8. Our vendors have active educational programs to teach the importance of quality, process-control techniques, and statistical process control.
9. Our vendors participate with us on quality planning, control, and improvement.
10. Our vendors share cost data on design areas with us.
11. Our vendors are willing to discuss and modify designs.
12. Our vendors participate with us in the development of specifications for their products.
13. Our vendors are involved in solving tomorrow's problems today through a continuous R&D program.
14. Our vendors have good facilities that are designed to produce quality parts.
15. Our vendors provide continuous maintenance on their real property to ensure that processes stay in control.
16. Our vendors provide to us evidence that their processes are under control, including statistical process-control charts.
17. Our vendors have the capability to surge production if we require.
18. Our vendors work with our engineers to develop operational definitions for critical quality characteristics.
19. Our contractual arrangements with vendors stress quality first.
20. Our vendors also have single-source arrangements and evaluate their vendors with criteria similar to ours.
21. Our vendors use statistical methods to maintain precision measurement equipment.
22. Our vendors employ statistical process control for never-ending improvements in all areas of their organization.

23. Our vendors employ the "extended process," which involves their suppliers, other customers, investors, and their total communities.
24. Our vendors establish corrective process loops to continuously improve their products.
25. Our vendors use customers' quality data reports provided by us to analyze and improve their products.
26. Our vendors provide samples of products as required.
27. Our vendors participate with us in inspecting and testing, and they provide reliability information when requested.
28. Our vendors provide to us their standard operating procedures for such things as design, engineering, and manufacturing changes.
29. Our vendors provide service on their products after delivery.
30. Our vendors do not have a history of solving disputes through litigation.[7]

When potential vendors are evaluated using the above criteria, the fear of single-source risk should be reduced. Some vendors supply services, consultation, and oversight. It is just as important in these cases as in manufacturing to move to single-source vendors selected by similar criteria.

Changing the Contracting Environment

Regardless of an organization's function, the selection of single-source vendors will require a change in the education and training of its buyers. Dr Deming has suggested that purchasing agents in a total quality organization of the future will have a different job. This new job will involve learning statistical process control and evaluating vendors based on the capabilities of their processes rather than their ability to prepare slick proposals.

Recall our example of the automative company that could reduce its vendors from 4,000 to 800. A reduction of 3,200 purchase orders/contracts might inspire some eager manpower engineer to issue pink slips, but this should not necessarily be the case. Although not all contract clerks that were used to process the 4,000 purchase orders in the past will be needed when the organization moves to 800, most will be needed.

In the new single-source organization, purchasing agents will fully know and appreciate the effectiveness of statistical process control (SPC). Buyers will use SPC to separate potential offers and select vendors based on their quality. After vendors have been awarded long-term contracts, buyers will evaluate their performance using SPC methods. The buyers will not be doing this in isolation, however; as part of the extended process, they will be part of the process action team that uses the parts they procured. As parts are integrated into larger components and SPC is used to control and improve processes, the buyer will be the vendor's spokesman, representing the product. If needed, the buyer will bring the vendor in to assist in special activities.

Buyers in the new quality organization will evaluate parts and work with the vendor to determine the appropriate stock levels that will meet

schedules and optimize production runs. Buyers will be responsible for far more than evaluating proposals and awarding contracts. Their responsibility will be carried through the entire process, and they will be aware of the results of their decisions through the use of SPC.

Buyers will have backgrounds in engineering, quality, manufacturing, business, and contracting; and they will be buyers only after they have been members of development and manufacturing teams. They will come to the buying organization with an understanding that quality parts result from quality processes. This will be a radical change for the buying organization, and the only way it will come about is through active and participative senior management.

Managers must be willing to say, "We are going to change the way our vendors are selected, and this change involves changing you. You will be required to learn new skills; you will be asked to take on new responsibilities; and you will work in other parts of this organization to understand the impacts of your buying decisions." They must stand by their decision to move to a single-vendor environment, and they must commit the resources and time required. They should support the following statements:

1. My organization will provide the needed training to qualify all buyers in statistical methods.
2. My organization believes that buyers qualify for their position by first working on a manufacturing or development process team.
3. My organization believes that if we select vendors based on quality, performance, and schedule, profit will follow.
4. My organization has established the goal of buying a part or service from only one vendor.
5. My organization will actively involve vendors in our continuous improvement and problem-solving processes.
6. My organization is committed to rating, tracking, and rewarding vendors who utilize the "extended process."
7. My organization is committed to providing the training necessary for our vendors to understand our products and processes.
8. My organization involves vendors in the development of specification and operating definitions they will be required to meet.
9. My organization is committed to contracting for quality processes and will work with vendors to ensure that we both receive what we need to remain healthy.
10. My organization will reward our best vendors with opportunities to receive more of our loyal business.

A New Philosophy

It may have seemed like the buying community was hit unduly hard in this section. This was not the intent. Buyers have done an outstanding job of executing the management directive—"buy cheap parts!" But the time has come for change in the buying community. Management owes the

organization a new vision, based on a single-vendor environment; it owes training, education, and rotation within the organization to ensure that buyers are quality team members.

Notes

1. USAF Scientific Advisory Board, *Report of the Ad Hoc Committee: Aircraft Infrastructure—Subsystem and Component Reliability Improvement Research and Development Needs "F-A-C-T-S"* (Washington, D.C.: AF/LE-RD, September 1989), ix.
2. Howard S. Gitlow and Shelly J. Gitlow, *The Deming Guide to Quality and Competitive Position* (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1987), 54.
3. Nancy R. Mann, *The Keys to Excellence: The Story of the Deming Philosophy*, 2d ed. (Los Angeles: Prestwick Books, 1987), 134.
4. Gitlow and Gitlow, 55.
5. William W. Scherkenbach, *The Deming Route to Quality and Productivity: Road Maps and Roadblocks* (Rockville, Md.: Mercury Press, 1988), 131.
6. Gitlow and Gitlow, 57.
7. Ibid. These criteria were derived from a series of questions offered by Gitlow and Gitlow for the purpose of selecting the right vendor.

Chapter 10

The Internal Process

To err is human; to pass it on is not this organization's policy!

—Anonymous

The most significant means to improve the overall quality of products and services in an organization is to improve its internal processes and everything that goes into or out of these processes. Elements of processes are requirements, materials, machines, environment, methods, and people. When each element is optimized for minimal variability, when standards are in place, and when a measurement system is evaluating performance, processes are said to be in control.

To ensure that processes are in control, organizations must use a structured system to obtain and maintain process controls. In addition, they must take the following actions:

1. Demonstrate a commitment to understand and improve all processes.
2. Provide goals for process improvement within the strategic planning process (SPP).
3. Establish an environment in which process improvement teams are responsible for specific processes and the processes' improvements.
4. Develop a cultural environment in which all members are encouraged to participate in process improvements.
5. Develop a cultural environment in which all processes are under review.
6. Establish a reward system that is capable of timely recognition of process teams that make significant and noteworthy improvements.[1]

Process Ownership

In order for processes to be controlled, they must be owned. Process ownership establishes responsibility and accountability for processes within an organization. Each process in an organization must have an owner. In organizations that utilize multiple teams, each team owns the process it has control over. In organizations that are hierarchical, each process is owned by the unit performing the work. In both cases, multiple processes are combined at higher levels in the organization to form process groups.

Matrix organizations present special problems for process ownership because they have split loyalties: primary loyalty to their functional organization and secondary loyalty to the organization(s) they are supporting. Process ownership should be identified here just as in other organizations. The more quality-conscious matrix organizations are concerned with internal customer satisfaction and will generally agree with ownership of the process by the supported group.

The importance of senior-level involvement is critical in dealing with this ownership problem. If leaders are not willing to make hard decisions on process ownership, they will be telling the entire organization that ownership and accountability are not required across-the-board. Any exceptions will be cause for more exceptions.

The process owner's greatest responsibilities are those of selecting, guiding, and maintaining strong and effective teams. Process owners must establish an environment that is supportive of total quality management, and they must promote the principles of a total quality leader. In addition, process owners must

1. know the requirements of the process,
2. receive the customer's concurrence on the identified requirements,
3. define all subprocesses that feed the process,
4. assign ownership of subprocesses where they are subordinate to the identified process,
5. identify team members,
6. validate the documentation of task-level procedures,
7. determine critical subprocesses and key dependencies,
8. establish a measurement system with appropriate targets to ensure continuous process improvements,
9. ensure the integrity of information for processes and measurements, and
10. resolve cross-functional/cross-team issues.[2]

Internal Process Improvement Model

The internal process improvement model (IPIM) is a 21-step process that enables organizations to identify process owners.[3] It develops process effectiveness and efficiencies, establishes the proper assessment system for processes, and fosters an environment for process planning. When this system is used without shortcuts, it will address all areas that need to be reviewed to ensure that processes produce quality outputs.

Process Identification

Process identification, the first phase of IPIM, contains five steps that identify the process and the owner, the customers of the process, and the

customers' requirements. After determining what the process is, who owns it, and whom it satisfies, the organization identifies any deficiencies in the measurement system and establishes corrective actions.

Step 1. Identify the process and its owner.
- Name the process.
- Name the owner.
- Describe the process. Identify what initiates the process, what is included in the process, and what the output of the process is. Identify both the suppliers that provide inputs into the process and the inputs themselves.
- Identify the subprocesses that together make up the process. Identify responsible individuals for each subprocess.

Step 2. Identify customer requirements for the output.
- Identify the customer of the process output.
- Identify what the customer expects to receive from the process.
- Through the MAIC process, determine how customer expectations will be achieved.
- Review MAIC with customers. Get their concurrence.

Step 3. Identify the measurement system.
- Identify the current measurement system.
- Determine whether it measures critical areas of importance to the customer.
- Identify areas that do not measure customer requirements.
- Identify areas where inspection is not needed.
- Identify new measurement areas.

Step 4. Identify deficiencies.
- Identify the deficiencies in the process.
- Identify the deficiencies in customer requirements.
- Identify the deficiencies in the measurement system.
- Identify process owner and worker deficiencies.

Step 5. Identify corrective actions.
- Identify corrective action for process deficiencies.
- Identify corrective action for customer requirements deficiencies.
- Add corrective items to the measurement system.
- Identify additional training to correct process owner and worker deficiencies.

The importance of IPIM's first segment is that processes are identified, customer expectations understood, and measurement systems reviewed. This provides a general understanding of the environment in which the process is developed. All materials and services that come into the process from suppliers and other processes should be reviewed. It is important in the early stages of IPIM that anything affecting a process be documented and reviewed. For this reason, it is helpful to develop a process flow diagram

that details all activities to the lowest level. The flow diagram helps determine where measurement points should be located and where streamlining could be effected.

Process Development

Use the process flow diagram to develop a standard process, describe it, and tell how it is best performed. This is similar to "work measurement" and "time and motion" studies, the difference being that the standard process is the best way of performing the task *at the present time*. Through continuous improvements, the standard process will become more efficient. It contains the key measurement indicators and the training required by process workers to put the change in place and install the new or revised process.

Step 6. Develop a standard.
- Start with the process flow diagram and define each process activity in terms that are understandable and repeatable.
- Develop process description sheets on each activity.
- Develop process acceptance sheets for each decision point on the process flow diagram.

Step 7. Verify changes against customer requirements.
- Review customer requirements and expectations against process acceptance sheets. Make sure they are consistent.

Step 8. Develop a measurement system.
- Develop defect-free criteria between process owner and customer.
- Develop a measurement system to check inputs at decision points.
- Insert special measurements where a customer product attribute is a key indicator of customer satisfaction.
- Use standard process control techniques throughout the measurement system.
- Do not rely on inspection.

Step 9. Train to new standard.
- Develop training packages to reflect the skills required to perform to the standard.
- Use self-training and team-training techniques.
- Train multiple team members so that more than one person can perform the task.
- Describe how the measurement system will work with the process to help maintain control.
- Educate process workers on customer requirements and the relationship between requirements and process.

Step 10. Make it happen.

- Initiate the new process standard.
- Initiate the measurement system.

Beware, though, the many hidden activities that for one reason or another have been ingrained into processes over the years. These activities may add little value to the process but have secured jobs for people as the processes grew over the years. Process streamlining in such cases is difficult but not impossible. It is important that workers who performed those noncontributory tasks be given the training necessary to perform relevant tasks.

Process improvement should not mean that jobs are at stake. Managers should make that clear at the beginning of process improvement. The producer and the customer must agree on the development of defect-free criteria, and process workers must understand them.

Process Assessment

In this phase, process improvement is effected through a review of the process standard and the measurement system and the establishment of prevention methods to keep the process on a defect-free track. Process improvement teams (PIT) are established to correct any defects found. PITs should also explore ways to prevent process defects, since prevention is more valuable than correction in the long run. Both are required to produce error-free products.

Step 11. Check the measurement system.

- Check for defects in the process and determine whether the measurement system failed.
- Add checkpoints to the measurement system where needed.
- Eliminate or reduce checkpoints where feasible.
- Ask whether the customer is satisfied.
- Change where needed.

Step 12. Check the standard process.

- Study the standard process for areas that can be improved. Make changes as needed.
- Look for simpler ways to perform the task.
- Involve the process workers—they are the best source of improvements.

Step 13. Check for deviations.

- Review processes for deviations. Audit each process against process check sheets.
- Reinforce the "right way" approach.
- Determine whether deviations are caught by the measurement system or are found further into the process.
- Look for ways to streamline the process.

Step 14. Check for causes.
- Use cause-and-effect diagrams to determine why deviations are occurring.
- Determine the root causes of deviations.
- Determine the effects of deviations.
- Correct causes of deviations.
- Reinforce commitment to one "right way" process.

Step 15. Check for prevention methods.
- Use cause-and-effect diagrams to determine where preventive measures can be installed in the process.
- Review task descriptions for impediments to error-free process execution.
- Establish feedback loops for high-defect process control points.

Next to training, a defect-prevention effort is the best investment an organization can make. Prevention methods are actively employed through process improvement teams and process owners, who together seek to continuously improve the process.

Process Planning

Change is inevitable in dynamic organizations. Because process planners recognize that change will occur, they design a system to accommodate change without upheaval. Process owners are better able to participate when change is planned.

Process planning requires a full understanding of the current process—its capabilities, strengths, and weaknesses. It also involves working very closely with the customers to determine what they will need. As information becomes known, process owners are able to plan, forecast, and design future training requirements, test and develop new processes, and develop revised measurement systems before they are needed. This allows time for customers and process owners to make critical decisions about future directions and activities. The best prospect for predicting the future is by planning it today.

Step 16. Monitor standard process.
- The baseline for future planning is the standard process as it is performed today.
- Ensure that the standard process is performing within established controls. If it is not, find out why.
- Continue interactive process improvements through streamlining, customer inputs, and measurements.

Step 17. Document standard process.
- The baseline document for future planning is the standard process document.

- Ensure that the standard process document reflects the standard process. Ensure that changes made to the process are made to the standard process document.
- The standard process document is the authority to do work in a particular way.

Step 18. Identify future requirements.
- Develop a method for the process owner and the customer to communicate their intentions.
- Communicate current capabilities to customers.
- Include customers in process improvement so they can see the extent of process capabilities.
- Solicit future requirements from customers.
- Document future requirements in a process modification plan.
- Get process owners and customers to agree on content.

Step 19. Document future changes to standard process documents.
- Review current standard process documents against future requirements and identify the differences.
- Program for future training requirements.
- Program for new machines.
- Work with suppliers to identify future requirements.
- Work with other process owners to prepare for a planned change.

Step 20. Develop new measurement control points and values.
- Obtain new customer expectations.
- Establish agreement between process workers and customers on measurement.
- Test measurement system against prototype process.
- Make adjustments as needed.

Step 21. Train process owners.
- Establish prototype process and train process owners on new process.
- Have process workers determine where process efficiencies and effectiveness can be maximized.
- Streamline and simplify process.
- Initiate new process.
- Return to step 6.

The IPIM may take as long as two yea' ɔ accomplish. That is why the model is divided into four phases. Each process owner in an organization should be tasked to complete phase 1 within three months of initiation. Phase 2 should take from three to six months to thoroughly complete, and phases 3 and 4 will take approximately one year.

The reason the process is as long as two years is that the organization must make sure that real processes are being measured. As changes are

made, it takes time for them to "settle in" and for new measurements to be taken and verified. It takes time to develop the standards, authenticate the results, and make adjustments. And as standards are developed, they must be audited. Process improvement teams must move cautiously, ensuring that the changes they are making do not have linkages to other processes.

Speeding through the IPIM would show some improvement but might cause problems for other processes. Take the time to plan process improvement, apply sufficient resources to do the task, and challenge every activity. Understand why it is being done and what value it adds to the process. Review and audit progress by answering the process improvement questions at the end of each phase.

Notes

1. Brian E. Mansir and Nicholas R. Schacht, *An Introduction to the Continuous Improvement Process: Principles and Practices* (Bethesda, Md.: Logistics Management Institute, August 1989), 4-53, 4-54.

2. *Total Quality Improvement: A Resource Guide to Management Involvement* (Seattle: Boeing Aerospace Co., 1987), 12.

3. Boeing, in *Total Quality Improvement*, developed a 10-step improvement process. Mansir and Schacht, in *Continuous Improvement Process*, developed two models: standardize-do-check-act and plan-do-check-act process improvement/learning cycle. They were based on the Shewhart Cycle, plan-do-check-act. These three models were used to develop IPIM, a substantial part coming from Boeing.

Chapter 11

The Measurement System

Inspections are much like closing the floodgates after the storm.

—Anonymous

Dependence on mass inspections of products or services is the least effective way to achieve quality, and inspecting organizations comprise the latest example of management's transferring responsibilities for quality to someone else.

As modern American organizations became more comfortable with someone else inspecting their products, individual workers became more distant from the responsibilities associated with their work. Today's managers say that quality is everyone's responsibility, yet no one is accountable. The organization's quality output is dependent on the quality inspector, who can reject items when the acceptable quality level is not high enough but who does not have the authority to correct problems.

Changes must occur in the workers' jobs and in the involvement of managers in the total process. Total quality organizations do not need inspection functions; rather, they need all workers, including management, to be responsible for their own inspections. Teams need the tools to perform their own inspections, quality needs to increase, productivity needs to rise, and customers need to be satisfied.

Performance Measurement System

In a total quality organization, inspection as we know it today will go away. Inspection in a quality-minded organization will encompass a two-level system. The performance measurement control system (PMCS) will be operated by individual workers and process teams; the performance management verification system (PMVS) will be operated by a special audit group identified by the head of the organization (fig. 31).

In total quality organizations, the focus of inspections is on the measurement system. If the product is meeting requirements imposed by the customer, quality has been achieved and the process is in control. If the process is in control and customers are satisfied, there is little need to review each subactivity against its requirements. Two examples will demonstrate

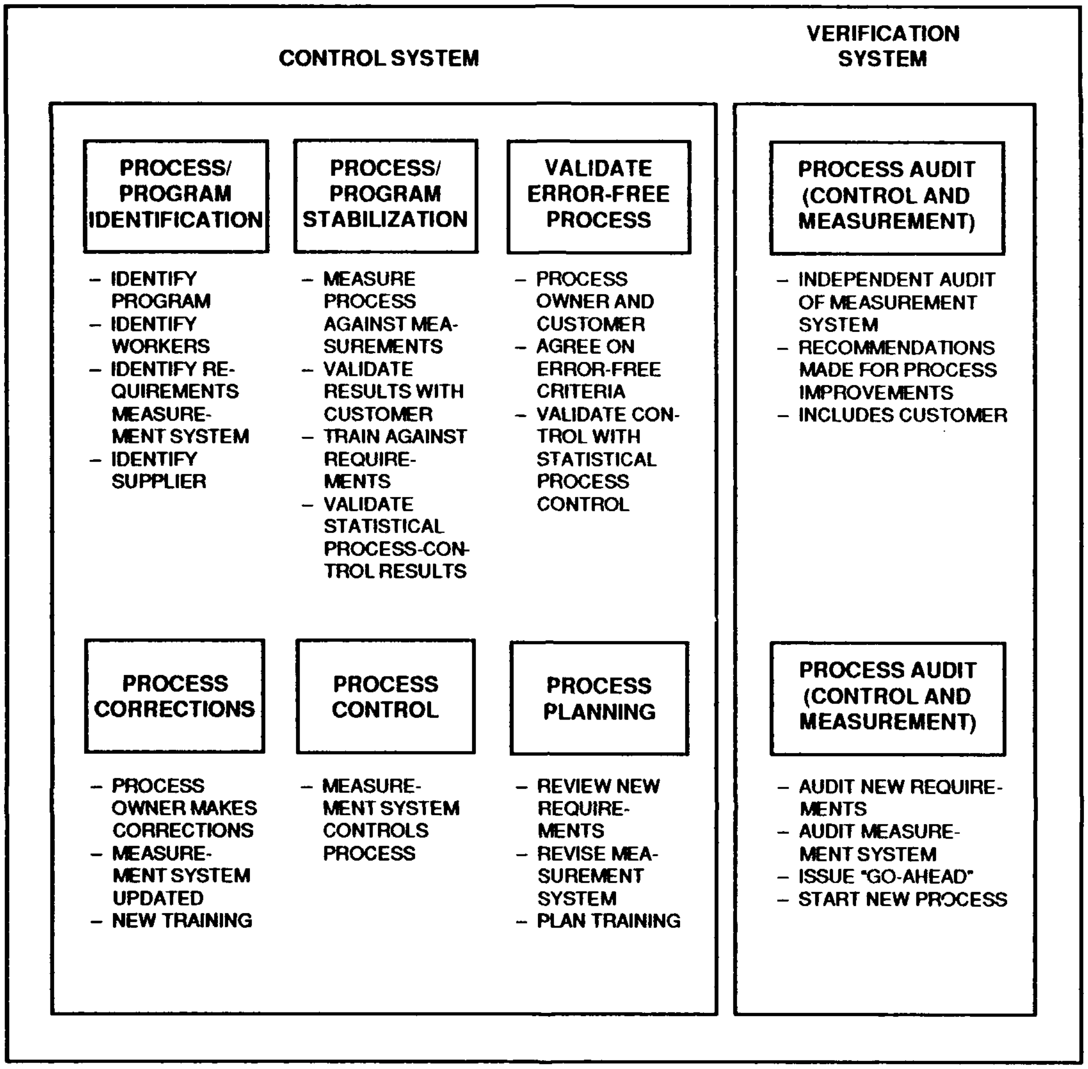


Figure 31. Performance Measurement System

why inspections using the classic approach do not ensure quality products. The first example involves a major program.

In late 1982 a system program office (SPO) was tasked to develop a new and advanced radar system. The SPO was organized, funding was inserted into the budget, and user requirements were defined. At the same time, documents that would affect the program through its entire life were being developed. Decisions were being made that would affect over 70 percent of the radar's life-cycle cost; yet less than 1 percent had been spent to develop, validate, and confirm the user requirements.

Parallel processes were attempting to satisfy different customers with different and sometimes conflicting requirements. Conflicts were resolved based on the information available and the time constraints involved. Two

years after the SPO was established, a full-scale development, fixed-price contract was signed for approximately $500 million.

The SPO was successful and considered to be one of the best. The program managers were considered among the best in their field. Three years after the contract was signed, they were to go through their first review by the inspector general (IG). Prior to the IG team's arrival, all program activity ceased while they "prepared" for the inspection.

The inspector general team members were thorough, investigating back to the beginning of the program. They looked at requirements documents, logistical analysis, and the contract; and they talked to the contractor. They declared the SPO to be satisfactory. Less than one year later, the contractor announced an 80 percent contract overrun. Soon after that, the contractor declared that some of the major user requirements would not be met—even at the increased cost.

Example two concerns Apex, a manufacturing plant that produces aircraft landing gear assemblies for major aircraft manufacturers in both the Northwest and the Southwest. Apex has been producing aircraft landing gear assemblies for many years, along with other highly sophisticated components. Its products have always been considered the standard for reliability and quality.

Apex has a small, highly skilled work force of master craftsmen. They joined the firm after WWII and received most of their training under the GI Bill. Apex managers have maintained a constant work force, bringing on new workers before older workers retired. Apex uses a classic organizational structure for manufacturing, marketing, business operations, accounting, and quality control.

Quality control, which represents about 5 percent of the total work force, inspects all processes and incoming parts and helps to determine the outgoing quality level. Management sets this level based on quality control recommendations and estimated warranty cost. All in all, the manufacturing plant is a well-run organization.

In 1985 an Apex customer reported high failure rates in an axle component assembly. Apex investigated and determined that all parts in the assembly were within specification, all materials were within specification, and all vendor-supplied parts were within specification. This information was reported to the customer.

The customer sent a process action team (PAT) to Apex to review the data. The customer's PAT confirmed what the plant managers had said, but also found that Apex had recently switched to a new vendor for machined shafts. Further investigation revealed that, while all parts supplied by this vendor were within specification, the actual measurements of the assemblies varied radically between the upper control limit and the lower control limit. The customer determined that the original specification was too lenient and required Apex to tighten it up.

The Focus of American Inspection Systems

In both examples above, the inspection system performed the task it was designed to perform. In the first, the IG team inspected the program against well-known standards and process requirements. The standards are so well known, in fact, that checklists were developed to prepare for inspections. These checklists are freely distributed and are even updated by the IG on a regular basis—one set of requirements for all programs—and, it is safe to say, are used only in preparation for an inspection.

The inspection process failed on this program and on countless others that have encountered similar problems. The reason for this failure was that process owners were not required on a continuous basis to measure processes they own against standards established by customers. The environment did not require process owners to look for ways to improve their process. By the time an inspection was performed, millions of dollars' worth of products had been released to customers. In many cases, even the customers did not know any better because they did not have an inspection system that required them to take the necessary measurements.

An environment in which products are accepted and measurements are not taken as the product is produced, or where customers do not have measurements to assess products when they are received, will lead to high cost and, eventually, to customers who determine that the product does not meet their needs. To avoid such a situation, producers and customers should use statistical process-control tools to evaluate each phase of the industrial process.

Example two is slightly different, but the underlying concern is the same. Although measurements were made as products were received from the vendors, they were little more than accept/reject measurements. If samples were within the specification, the products were accepted. As new vendor parts were introduced, process owners could not determine whether their process remained within control. Had measurement tools been available, parts with wide variations would have immediately alerted the process owners, and an effective measurement system would have immediately detected the variation.

Measurement systems must be integrated into every critical process in the organization. Organizations must establish environments of continuous process improvement, use statistical process-control techniques, and encourage all employees to be actively responsible for the quality of the organization's products.

Inspections Are Out

Before the two levels of measurement are discussed in detail, we will dispose of the word "inspection" and not use it again. It implies an investigation after the fact. In most applications, inspections are performed after the processes have been performed. Inspecting after the process has been performed allows inferior products to be released to customers, allows

cost to accumulate before errors are discovered, and does little to reduce variability and increase quality. It is not needed in a total quality organization.

The performance measurement system (PMS), installed properly, becomes the culture of continuous improvement. To better understand the significance of the cultural change, we will look at some possible questions in a typical exchange between a member of the quality resources team (QRT) and the leader of a newly formed PAT. The organization intends to develop a new radar. The setting is a monthly PAT review. QRT members may ask the following questions:

- How many decision points are in the process's flowchart?
- Where did you install measurement nodes?
- Where is the feedback loop?
- During your imagineering session, were you able to isolate the areas that would provide the highest improvement at the least cost?
- What were some of the alternatives that you rejected during brainstorming?
- Did you use nominal group technique to arrive at the preferred means in your brainstorming session?
- May we see your cause-and-effect diagram on that problem?
- What is the ranking of each item in your quality function deployment matrix?
- Why doesn't the perception analysis support your position?
- If the Pareto chart you provided is correct, you are now proposing to focus your efforts on the fifth most important element. Why not the first?
- This histogram clearly shows a bimodal distribution, but your approach to solve the problem will only address a single modal occurrence. Why?
- We have tracked your time-from-start-to-finish performance on this activity as compared to similar activities throughout the organization. Your activity falls outside the lower control limit of the control chart. What are you not doing in this process?

One major benefit of PMS is that the same tools are used by the workers and by those who audit the output. Process owners use the PMS tools to ensure that their processes stay within control, are focused on the right activities, and are properly planned and executed. Process auditors review the process owners' use of the PMS tools, not the output of the process. Process outputs (products) are reviewed only when such reviews will help verify a finding.

Process auditors are part of the quality review team, which is headed by the senior officer in the organization. The senior officer frequently participates in annual audits, as do the directors of functional areas. Participation by senior-level members is critical for three reasons: first, it simplifies the process of communicating with senior executives; second, it makes the

likelihood of action more immediate;[1] and third, it establishes the executives' direct responsibility.

PMS Toolbox

The PMS toolbox contains various tools that are used by a total quality organization. Usage depends on the problem being worked, the process being measured, and/or the phase of process. The toolboxes used in PMCS and PMVS are basically the same; everyone in the organization will know and understand their basic use.

Before we open the toolbox, however, we must discuss statistical process control (SPC) and statistical quality control (SQC) and some terms used uniquely in the quality area. To facilitate that discussion, we will review some definitions.

- *Process:* Any combination of machines, tools, methods, materials, and/or people that results in a product or service. A change in any one of these constituents creates a new process.
- *Control:* The control process measures performance and compares it with a standard. The quicker the response to deviation from the standard, the more uniform the produced quality.
- *Statistical process control:* The application of statistical techniques for measuring and analyzing the variation in processes.
- *Statistical quality control:* The application of statistical techniques for measuring and improving the quality of processes. SQC includes SPC, diagnostic tools, sampling plans, and other statistical techniques.[2]
- *Correlation:* Correlation relates causes or symptoms of problems to an identifiable variable. Correlation looks for possible relationships between processes or products. This is a visual correlation, not a precise correlation coefficient. It does not require the mathematical processes of regression and correlation analysis. It can be seen in matrixes, scatter diagrams, and correlation charts.[3]
- *Stratification:* Stratification assigns discriminators to data points on a scatter diagram to make any relationships between the data more visible. Suppose a manufacturing company purchased widgets from three suppliers and each supplier offered several levels of quality, charging more for higher quality widgets and less for lower quality widgets. The manufacturing company wants to know whether more expensive widgets last longer than less expensive ones. The data can be plotted on a scatter diagram with widget cost on one axis, widget service life on the other (fig. 32). This scatter diagram reveals little, if any, relationship (correlation) between cost and service life. The manufacturing company cannot predict from this diagram how much service life any widget is likely to have.

Stratification may reveal very useful information from the same data, however. Suppose the data are stratified by supplier (fig. 33). Stratification

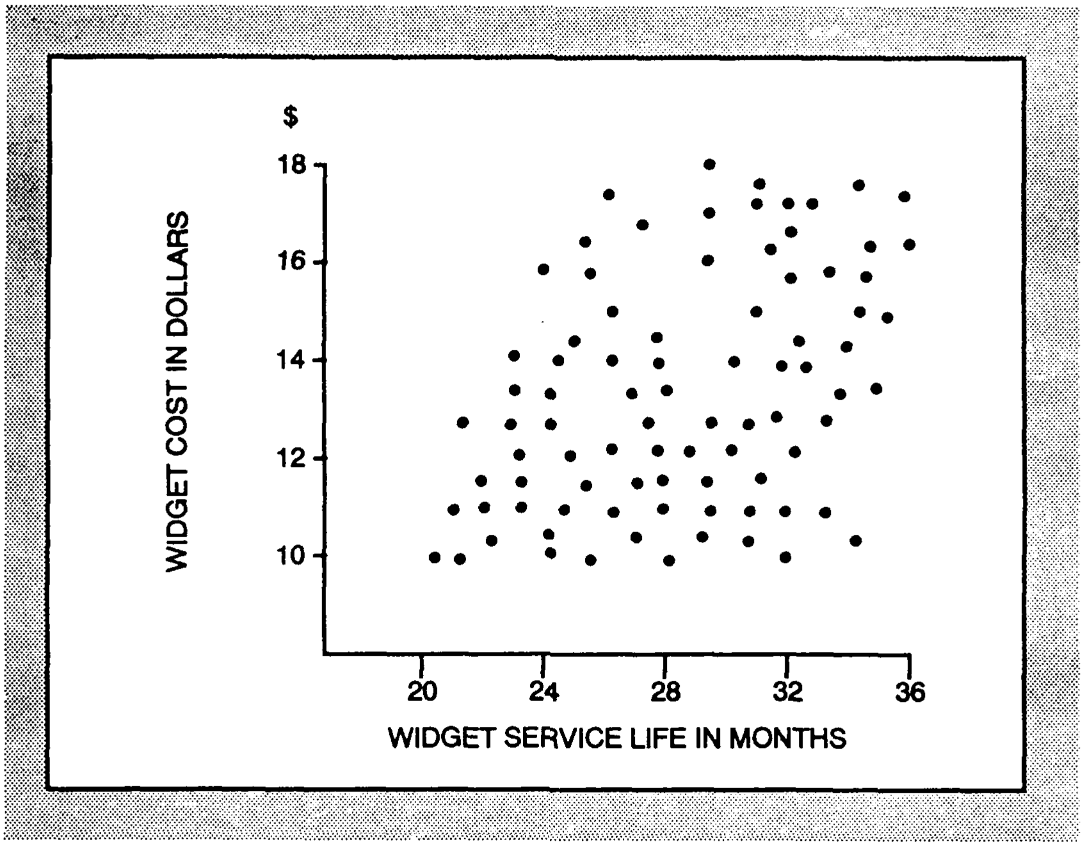


Figure 32. Widget Cost and Service Life

reveals correlations between cost and service life for suppliers A and B, while supplier C's relatively inexpensive widgets are just as likely to last 18 months as 34 months—or any number of months between 18 and 34. Stratification also reveals that supplier A delivers more service life per dollar than supplier B, even though the correlation between cost and service life for supplier B is just as great as that for supplier A.

The following format will be used to describe the PMS tools:

- *What is it?* A description of the tool.
- *What is it useful for?* What the tool provides the user.
- *When should it be used?* The conditions under which it is most beneficially applied.
- *How is it done?* A step-by-step description of how to use it.

Table 9 is a listing of the tools covered in this chapter. The tools selected have survived time and fad, and will be useful to a total quality organization. They are not presented in any particular order. Table 9 also indicates the applications the tools are best suited for.

Appendix C provides a listing of over 500 different areas in which measurements can be established in an organization. This appendix and

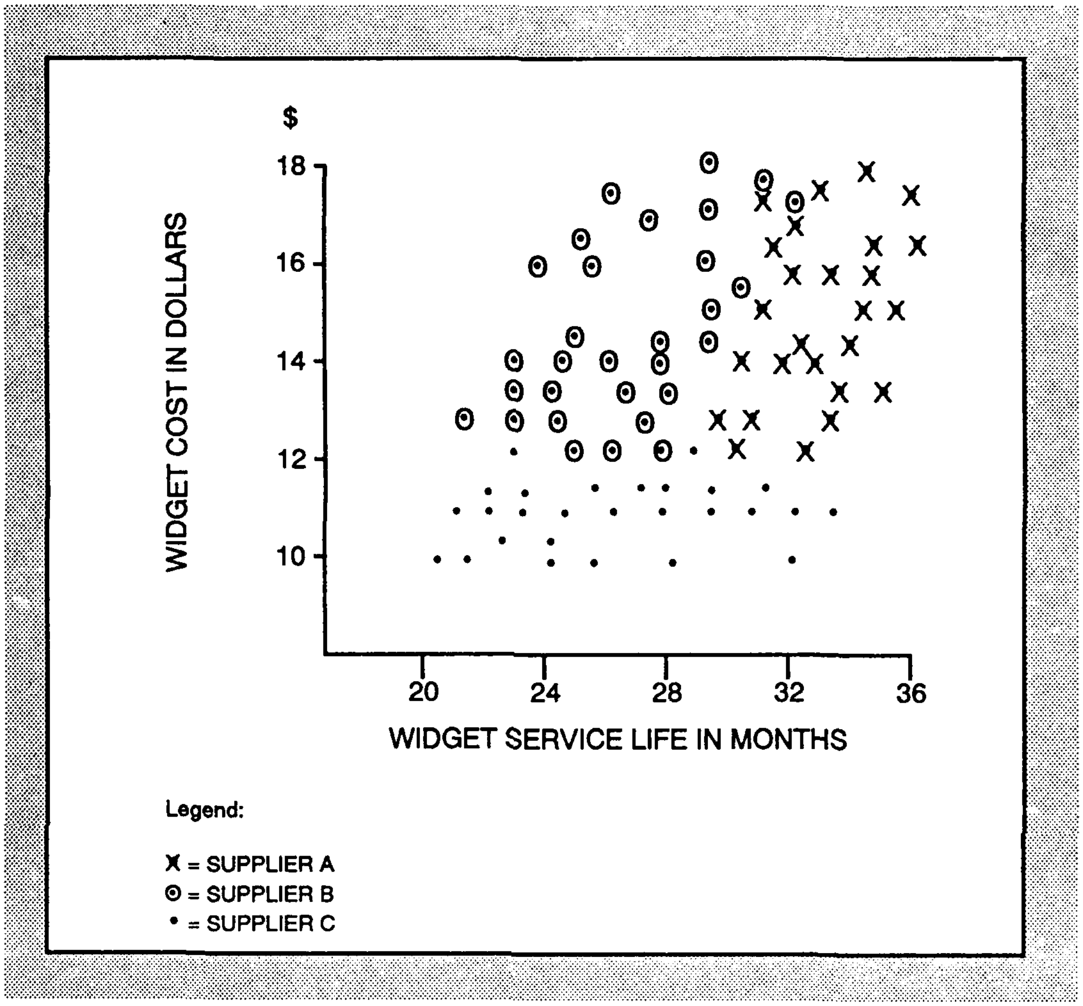


Figure 33. Widget Cost and Service Life, Stratified by Supplier

the 26 tools listed in table 9 comprise a good beginning for an organizational performance measurement system.

1. *Arrow Diagram.* The arrow diagram is a simplified form of the program evaluation and review technique (PERT). It is used to quickly find the least amount of time required to complete a project. It should be used to determine parallel processes, dependent links, and a rough critical path. It can also be used to simplify a PERT/critical path method (CPM) program for review by senior managers.

Start at the objective and work backward, identifying each process that must be accomplished to meet the objective. After each supporting process has been identified, go forward and add what may have been missed the first time through. Make sure that dependencies are linked to each supporting process. The arrow diagram in figure 34 shows three routes to the finished process.

Table 9

Performance Measurement System Toolbox

TOOLS AND TECHNIQUES	PROBLEM SOLVING/IMPROVEMENT ACTIVITIES					
	IDENTIFY PROBLEM	GATHER INFORMATION	ANALYSIS	GENERAL ALTERNATIVES	EVALUATE	PLAN AND IMPLEMENT
ARROW DIAGRAM			X		X	X
BENCHMARKING		X	X			
BRAINSTORMING		X		X		
BREAKTHROUGH THINKING	X	X	X	X	X	X
CAUSE AND EFFECT DIAGRAM	X	X	X			
CHECK SHEET		X	X			
CONTROL CHART			X			
CORRELATION CHART	X	X	X		X	
DEPLOYMENT CHART		X			X	X
FLOWCHART			X			X
HISTOGRAM		X	X			
IMAGINEERING			X		X	X
INPUT/OUTPUT ANALYSIS	X		X			
MATRIX CHART		X	X			
NOMINAL GROUP TECHNIQUE		X		X		
OPPORTUNITY CYCLE	X			X	X	
PARETO CHART	X	X	X			
PERCEPTION ANALYSIS	X	X	X		X	
PROGRAM EVALUATION AND REVIEW TECHNIQUE		X	X		X	X
PLAN-DO-CHECK-ACT					X	X
PROCESS DECISION PROGRAM CHART	X		X		X	X
QUALITY FUNCTION DEPLOYMENT	X		X		X	
RAINBOW CONTROL CHART	X					
SCATTER DIAGRAM AND STRATIFICATION	X		X			
TIME MANAGEMENT			X			
WORK FLOW ANALYSIS			X	X		

2. *Benchmarking.* Benchmarking is a way to graphically portray a process and compare it with known successful processes. It is a way to

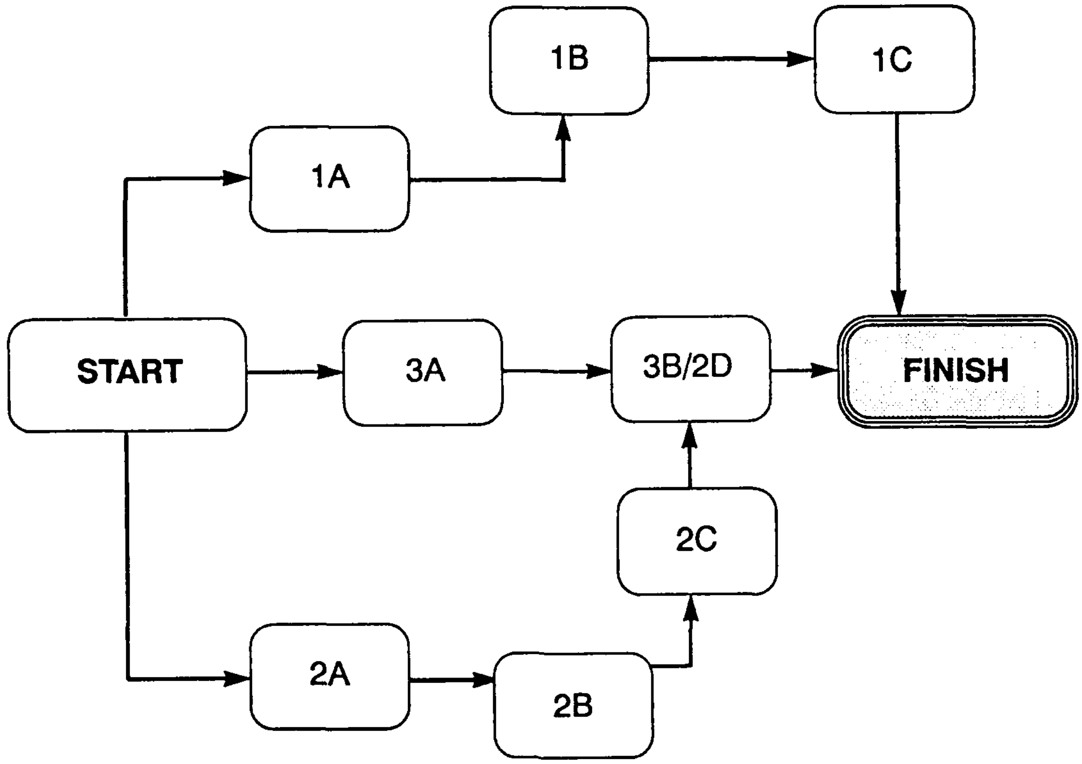


Figure 34. Arrow Diagram

view process status at any given time. The benchmark is used as a motivational tool. It shows how an organization stacks up against its competitors. It can compare process against process, similar function against similar function, or organization against organization. Benchmarking should be used whenever different organizations have similar functions and when the necessary tools are available for measurements that can adequately judge their progress.

• Identify the objective to be benchmarked: process, function, or organization.

• Determine its key characteristics. Then identify other organizations that possess similar processes or functions.

• Collect regularly available data and determine the rank order of the objectives.

• Place all objectives from other organizations on the right-hand side of the benchmark.

• On the left-hand side, put this organization's objective in its relative position (fig. 35).

3. *Brainstorming.* Brainstorming is a process wherein members of a group are asked to freely suggest possible solutions to a problem. The idea is to identify as many potential solutions as possible. Therefore, people who

Figure 35. Benchmark

have differing perspectives should participate. Brainstorming should be used whenever large numbers of ideas are needed. It can also be used to establish goals and objectives or methods of achieving them.

- Isolate the brainstormers group in an area where they will not be disturbed. Identify the purpose of the group.
- Tell the group members that each of them will be expected to provide at least one suggestion. Give them a few minutes of quiet time to jot down ideas.
- Encourage them to prioritize their ideas so that the first round will generate the best ideas.

• Ask the members for their ideas. Take one idea from each member and write each idea on a flip chart or chalkboard.

• After these ideas are written down, invite discussion and encourage the group members to build on each other's ideas.

• If necessary, go back to each group member for another idea. Repeat this procedure until sufficient numbers of good ideas have been recorded.

4. *Breakthrough Thinking.** Breakthrough Thinking is a problem-solving technique. Developed by Gerald Nadler and Sohozo Hibino, it is based on seven principles: *uniqueness; purpose; solution-after-next; systems; limited information collection; people design; and betterment time line.*[4] Breakthrough Thinking should be used to look at problems or make decisions. It is used to identify potential problems, demonstrate that problems in one element impact other elements, and examine both immediate solutions and the solution-after-next. It is particularly useful if time is limited, there is little supporting data, and an immediate solution is only one step in a continuous improvement process.

The best way to understand Breakthrough Thinking is to read Nadler and Hibino's book of the same title. The process is identified in table 10 below. (Table 10 is not intended to be a "how to," but rather a primer for further investigation.)

Table 10

Breakthrough Thinking

1. Recognize that each problem is unique and that problems with similar characteristics may not yield similar results.
2. Focus on the required correction, not the ancillary difficulties the problem is causing.
3. Identify the solution that cures the immediate problem, then identify the cure for that solution.
4. Identify the system the solution must fit into to work.
5. Limit the time and information available for arriving at a decision.
6. Identify and give recognition to the people who must work with the solution, and give them sufficient freedom to operate.
7. Select the best "solution-after-next."
8. Plan to monitor and continuously improve the "solution-after-next."

5. *Cause and Effect Diagram.* The cause and effect diagram, sometimes called the fishbone diagram or the Ishikawa diagram (after its creator), is used to display possible causes of a problem.

The effect or problem is put on the charts first. Then possible causes, divided into major areas, are placed on it. The cause and effect diagram should be used after the problem has been isolated, data has been collected,

* Breakthrough Thinking is a registered trademark of Gerald Nadler and Sohozo Hibino.

and sufficient information is available to determine why a particular event occurs.

• Describe the problem in a few words. Place the description on the right-hand side of the chart and draw a horizontal line to it.

• List the possible major causes of the problem along the axis of the line drawn to the problem (fig. 36).

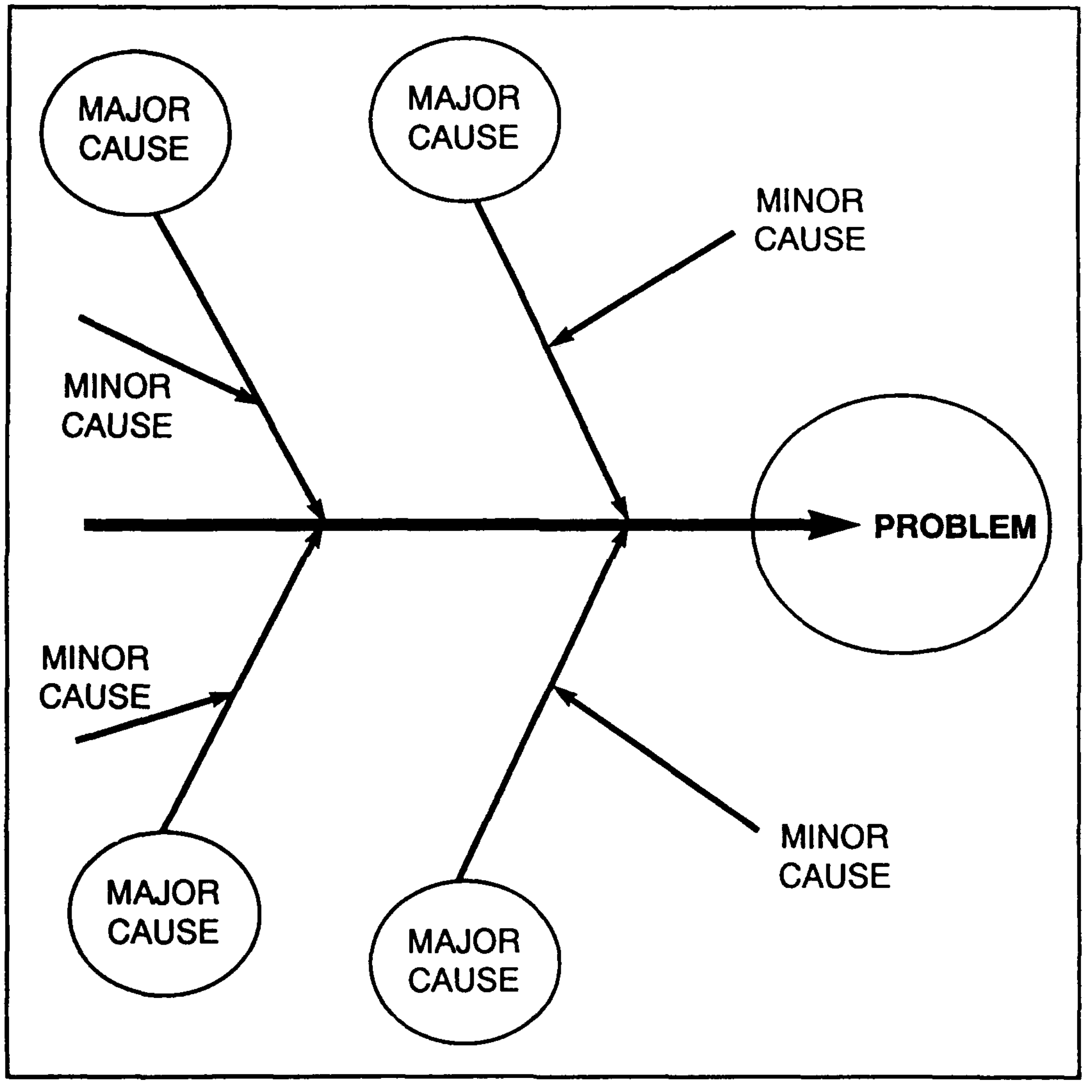


Figure 36. Cause and Effect Diagram

• Support each of the major causes by determining reasons.[5]

• Determine the most likely minor causes, and put them on the chart in support of the major causes. There should be at least two minor causes for each major cause.

6. *Check Sheet.* Check sheets are forms for recording error information during the data collection phase of process measurement. They are easily understood and used, and they offer a standard means to record defect information such as causes, locations, times, and operators. This information is later consolidated in a data base for statistical analysis.

Check sheets are used in all measurement processes. They maintain the data from recording to data base (table 11).

Table 11

Check Sheet

Errors in Contract Preparation

SECTION	*MARCH*	*APRIL*	*MAY*	*TOTAL*
A	2	3	4	9
B	7	5	10	22
C	20	16	20	56
D	2	2	2	6
E	3	2	4	9
F	1	0	1	2
G	3	3	5	11
TOTAL	38	31	46	115

- Identify the process and data to be recorded. During the process-development phase, develop the check sheets and validate them.
- Establish procedures for collecting the data.
- Record the data on the check sheet. Use slashes, Xs, or check marks.
- Tabulate the data at the conclusion of the measurement period and enter it in the data base for statistical processing.
- Check to ensure that check sheets are capturing error data as intended.

7. *Control Chart.* The control chart is a time and function chart as well as a boundary chart. Time is recorded on one axis, a measurement on the other. Boundaries are established as upper and lower control limits. The average or mean is also shown. The most common control chart is the $\overline{X} - r$ (pronounced "bar XR") type. The bar above the X indicates the mean, or average. The $\overline{X} - r$ chart is used to record discrete measurements such as weights, volumes, lengths, and speeds.

Control charts are used to portray process variation. Measurements that fall outside the upper control limit or the lower control limit indicate increased variation. The highest quality is achieved in processes that operate with very little variation. Control charts are also helpful in distinguishing between common-cause variation and special-cause variation. Common-cause variation is inherent in the process and can be corrected

only if basic changes are made in material, people, machines, methods, or environment. Special-cause variation, which is caused by some force outside the process, is more easily identified and corrected.

Control charts should be used whenever a need exists to know the range of variation in products or services being produced.

a. Use data from check sheets that collectively contain 100 or more distinct measurements. For purposes of illustration, we will use the following control chart with the first five columns filled in, and work to fill in the last two columns, $\overline{X}$ (mean value) and r (range).

Subgroup	*March*	*April*	*May*	*Total*	$\overline{X}$	*r*
Sec A	2	3	4	9		
Sec B	7	5	10	22		
Sec C	20	16	20	56		
Sec D	2	2	2	6		
Sec E	3	2	4	9		
Sec F	1	0	1	2		
Sec G	3	3	5	11		
Total	38	31	46	115		

b. Data on the check sheet should be divided into subgroups that are recorded under like conditions and from only one lot, date, time, and so forth. One subgroup in this example is Section A. The number of subgroups (k) is seven. The number of measurements (n) for each subgroup is three.

c. Determine the mean value ($\overline{X}$).

$$\overline{X} = \frac{x_1 + x_2 + x_3}{n}$$

For Section A subgroup, the data would look like this:

$$\overline{X} = \frac{2+3+4}{3} = \frac{9}{3} = 3$$

$$\overline{X} = 3$$

Repeat this process for each subgroup and fill in the $\overline{X}$ column on the control chart.

d. Compute r (range) for each subgroup.

$$r = x_{max} - x_{min}$$

For Section A subgroup, the data would look like this:

$$r = 4 - 2$$

$$r = 2$$

Repeat this process for each subgroup and fill in the *r* column in the control chart.

e. Compute the overall mean value ($\bar{\bar{X}}$) by summing the total $\bar{X}$s for all subgroups and dividing by the number of subgroups (*k*).

$$\bar{\bar{X}} = \frac{\bar{X}_1 + \bar{X}_2 + \bar{X}_3 + \bar{X}_n}{k}$$

In our example, it will look like this:

$$\bar{\bar{X}} = \frac{3 + 7.33 + 18.67 + 2 + 3 + .67 + 3.67}{7}$$

$$\bar{\bar{X}} = 5.48$$

It is important here and in the next step to compute the result two digits beyond the decimal.

f. Next, compute the average range ($\bar{R}$).

$$\bar{R} = \frac{r_1 + r_2 + r_3 + \ldots r_n}{k}$$

In our example, it will look like this:

$$\bar{R} = \frac{2 + 5 + 3 + 0 + 2 + 0 + 2}{7}$$

$$\bar{R} = 2.00$$

When you have completed the columns, the control chart should look like this:

Subgroup	*March*	*April*	*May*	*Total*	*X*	*r*
Sec A	2	3	4	9	3	2
Sec B	7	5	10	22	7.33	5
Sec C	20	16	20	56	18.67	4
Sec D	2	2	2	6	2	0
Sec E	3	2	4	9	3	2
Sec F	1	0	1	2	.67	0
Sec G	3	3	5	11	3.67	2
Total	38	31	46	115	$\bar{\bar{X}} = 5.48$	$\bar{R} = 2.14$

g. This step computes the control limits for the control chart graphic.*

For $\overline{X}$ Control Chart	*Our Example*
Center Line (CL) = $\overline{\overline{X}}$	5.48
Upper Control Limit (UCL) = $\overline{\overline{X}} + A_2\overline{R}$	5.48 + (1.023)(2.14) = 7.67
Lower Control Limit (LCL) = $\overline{\overline{X}} - A_2\overline{R}$	5.48 − (1.023)(2.14) = 3.29
For $\overline{R}$ Control Chart	
Center Line (CL) = $\overline{R}$	2.14
Upper Control Limit (UCL) = $D_4\overline{R}$	2.575 (2.14) = 5.51
Lower Control Limit (LCL) = $D_3\overline{R}$	.076 (2.14) = .16

h. Plot the data from $\overline{X}$ and $\overline{R}$ computations for each subgroup. The upper half of the $\overline{X}-\overline{R}$ chart contains the X data while the lower half of the chart reflects the range of each subgroup. Plot the center line for both $\overline{X}$ and $\overline{R}$ and upper and lower control limits for each. After this is done, plot data in the $\overline{X}$ chart and the $\overline{R}$ chart. When it is complete, your data should look like figure 37.

i. Continue to update and plot data as it becomes available. The data from figure 37 leads one's attention to the large number of errors in sections B and C of the contract. With this knowledge, the next step could be to develop a Pareto chart to see the type of errors occurring and apply the appropriate corrective action. After corrective action has been applied and data recomputed, the mean, range, and control limits will change, and the variability of the process will improve.

8. *Correlation Chart.* A correlation chart portrays the relationship between two sets of data. Similar in appearance to a scatter diagram,[7] it is used to visualize the degree of relationship between two sets of data. A correlation chart should be used when such relationships may exist, sufficient data is available, and clear symptoms can be isolated. When more than one factor may affect the same problem, correlation charts show which factor has the greatest degree of relationship.

- Identify the symptom.
- List the possible causes.
- Determine which possible causes have the greatest potential for being the actual cause.
- Plot cause measures on the x axis and symptom measures on the y axis, and draw a line between the plot prints (table 12 and figure 38). Plot each possible cause on a separate chart that can be compared with the others.

*The factors for $\overline{X}$ and $\overline{R}$ charts were derived from the early work of Dr Walter A. Shewhart while he was at Bell Telephone Laboratories. The terms "A_2," "D_4," and "D_3" refer to coefficients developed for calculating upper and lower control limits. These "constant" values vary with size of subgroup and number of subgroups. Examples can be found in Kaoru Ishikawa, *Guide to Quality Control*, 68.[6]

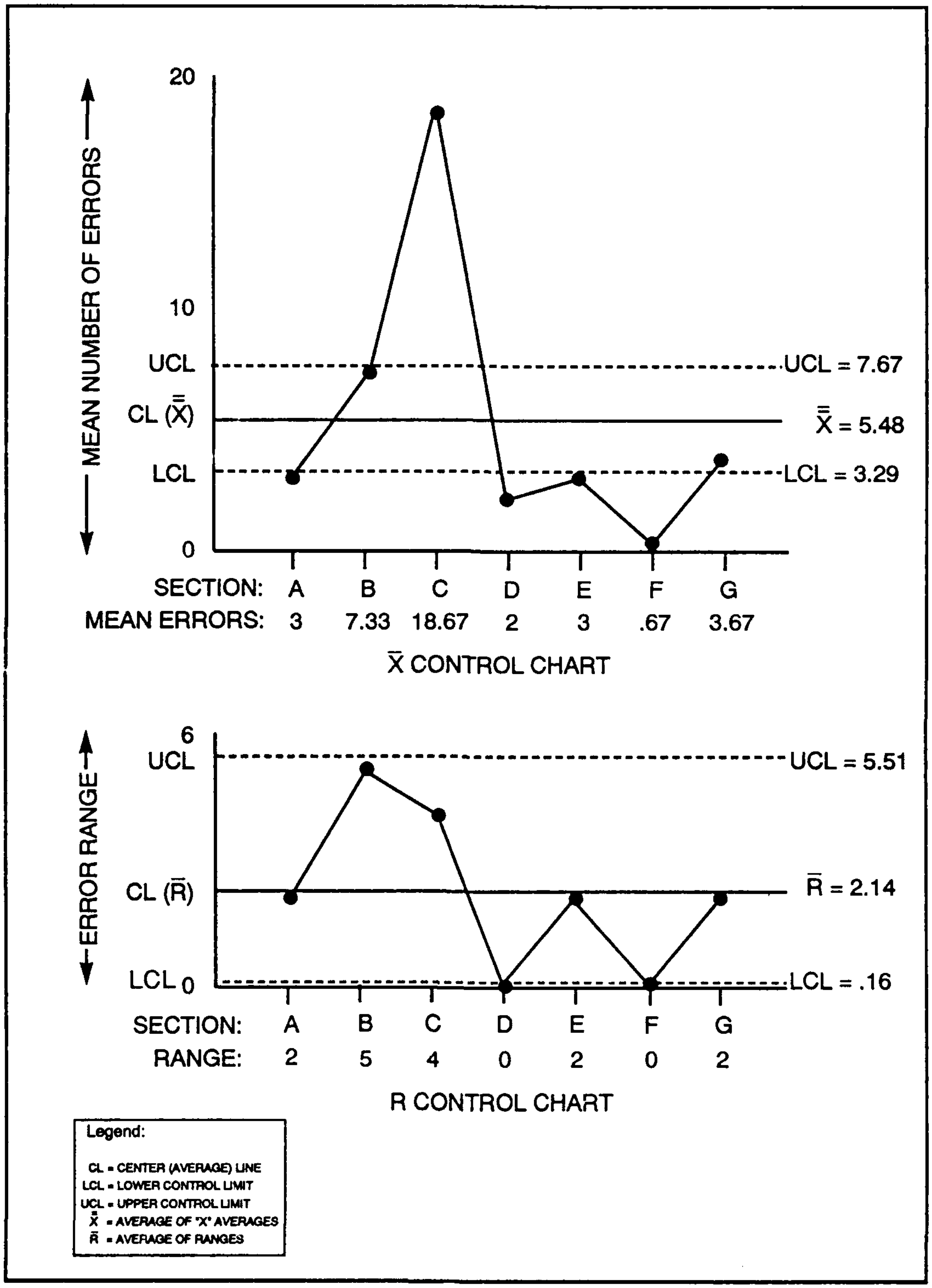


Figure 37. Control Chart Graphic

Table 12

Correlation Data Sheet

TYPE	VARIABLES	
	COST	SPEED
CORVETTE LT-2	$48K	169
CAMARO	$19K	127
VEGA	$10K	69
CORVETTE	$32K	150
FIREBIRD	$21K	128
CHEVY II	$9K	68

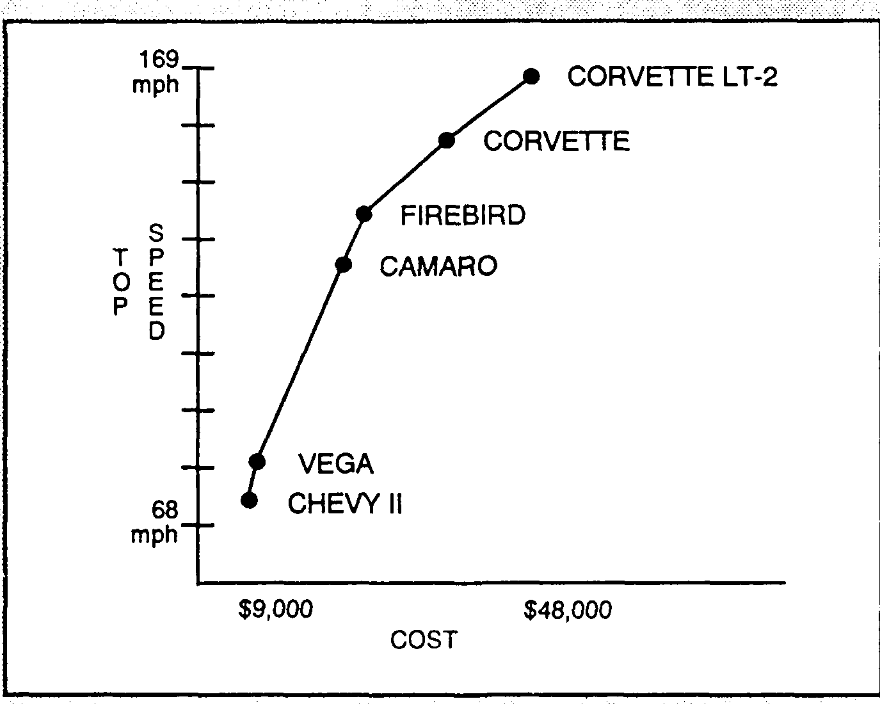


Figure 38. Correlation Chart

9. *Deployment Chart.* Two elements of information are combined in the deployment chart: the sequence of activities in a project and the individual or unit responsible for each activity. Deployment charts are useful in keeping track of the project and worker responsibilities. They should be used to identify the major phases of a project and the responsibility for each phase.[8]

- List the phases of the program down the left side of the chart.
- Across the top, list the team members or groups.
- Draw lines between the vertical and horizontal data to form rows and columns.
- Starting at the upper left corner of the chart, mark the activity and individual or group responsible for it (fig. 39). Rectangles represent primary responsibility, ovals represent support responsibility.

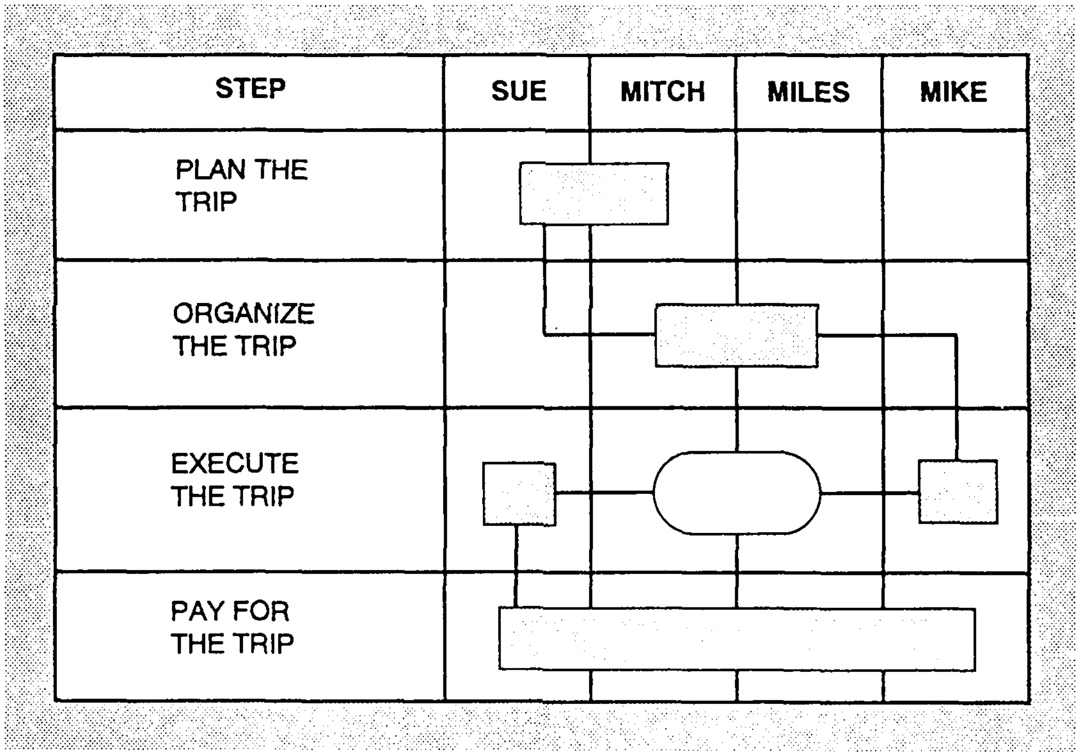


Figure 39. Deployment Chart

10. *Flowchart.* The flowchart (sometimes called a flow diagram) is the fundamental graphic representation of a process. It is a way of visualizing the entire process at one time. Lower-level processes flow into higher-level processes or are combined with other lower-level processes to make higher processes. The Gilbreth flowchart is used in TQM to depict the steps and communicate the essence of a process (fig. 26, chap. 7).[9]

Flowcharts are used to visualize how all the pieces of a process come together, where integration occurs, and what components and subprocesses are included. Flowcharts can be simple (table 13) or complex (fig. 40). They vary from a simple description of the process to a detailed depiction of the work contained in the process.

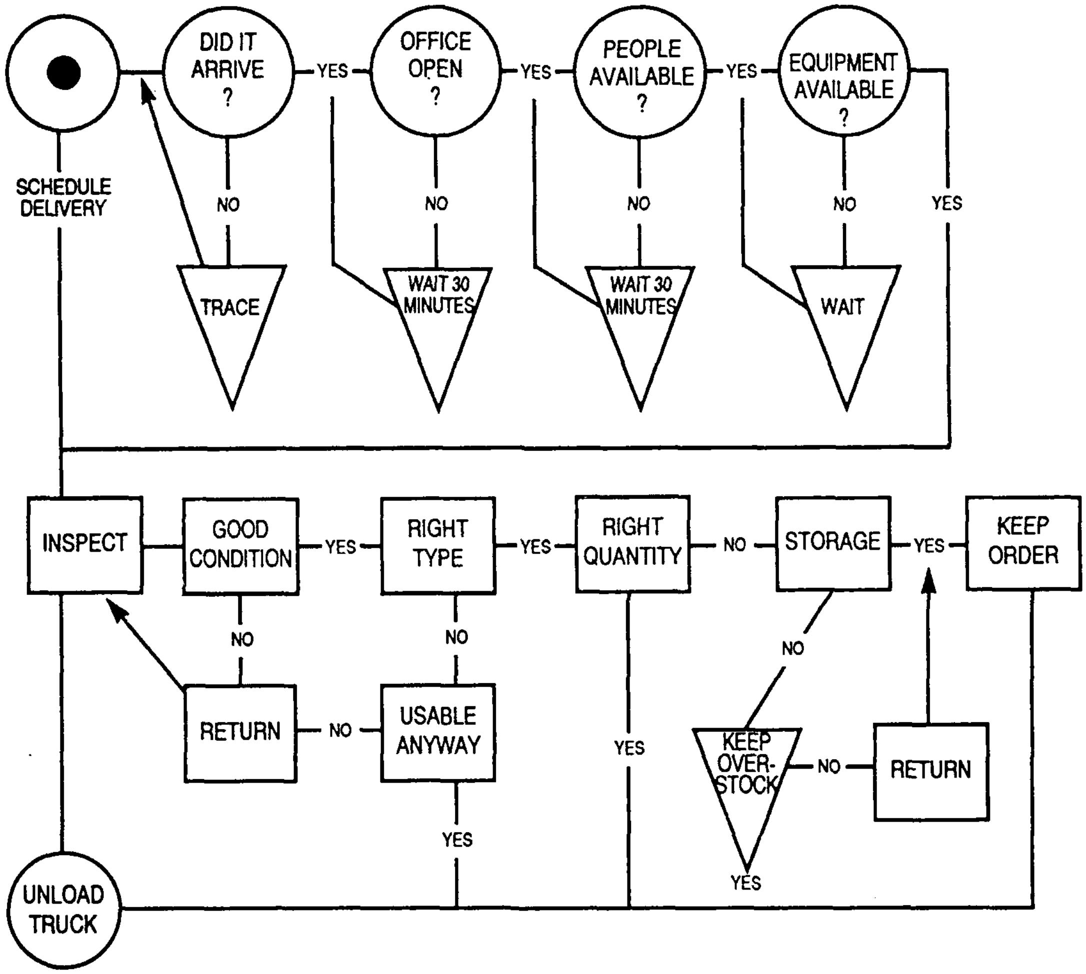


Figure 40. Detailed Flowchart

A flowchart is usually the first graphic description of a process. It should be used in developing the process, streamlining for efficiency, and planning test nodes for measurement. It is very useful in analyzing the relationships between various activities in a process and in identifying problem areas. It can also be used to analyze customer or vendor activities.[10]

- List all major elements of the process. Sometimes it is easier to start at the end of the process and work backward.
- Use Gilbreth symbols to construct the relationships and connect the processes to each other (figs. 41 and 42).

• If this is a new process, construct the flowchart as it should be. If it is a process under review, construct the flowchart as it actually is.

• If detailed design review and analysis is going to be done, develop lower-level flowcharts that support each of the single-process nodes identified in the top-level flowchart.

Table 13

Simple Flowchart

Plan the Trip	*Organize the Trip*	*Execute the Trip*	*Pay for the Trip*
1.1 Determine Destination	2.1 Determine Requirements	3.1 Rotate Driving	4.1 Total All Charges
1.2 Gather Maps and Info on Destination	2.2 Determine Hotels and Stops	3.2 Provide Navigation	4.2 Determine Share of Costs
1.3 Identify Route	2.3 Cost Estimate	3.3 Collect Charges	4.3 Collect Money
			4.4 Pay Bills

11. *Histogram.* Histograms portray frequency distributions in block form. The area of each block or column represents the number of scores in that interval.[11] The difference between a histogram and a Pareto chart, which looks similar, is that a histogram displays scores while a Pareto chart displays characteristics.

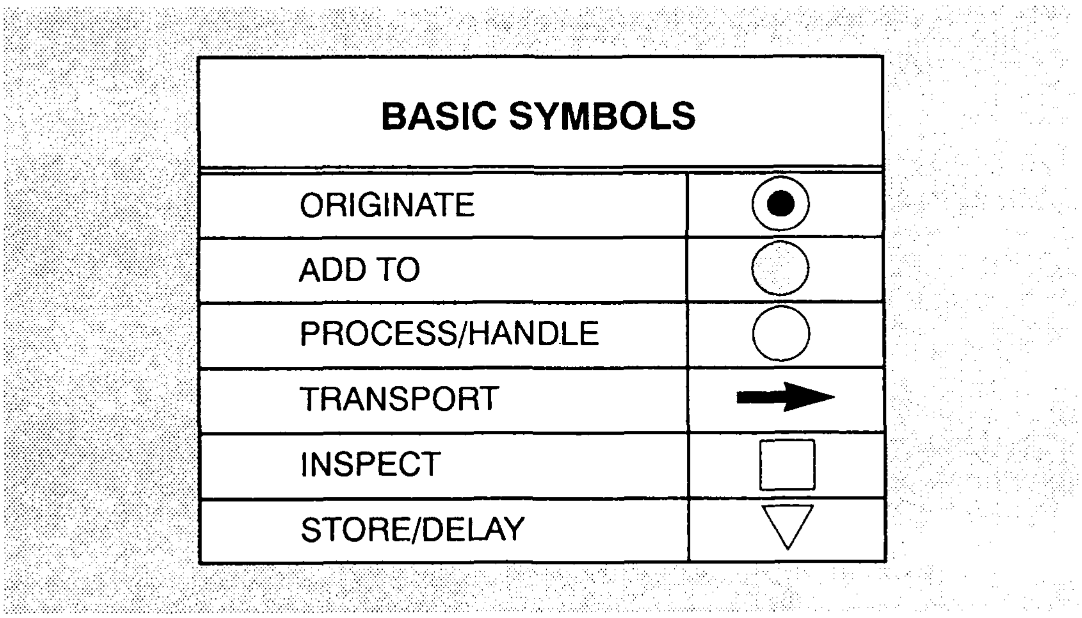


Figure 41. Basic Gilbreth Flowchart Symbols

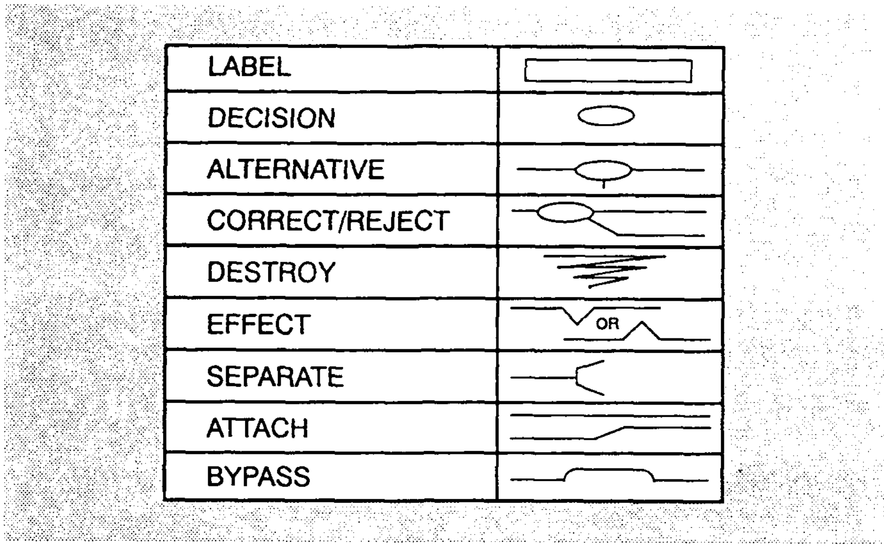


Figure 42. Action Symbols

Histograms are used to convert large amounts of data into an easily understood graph form. They can indicate whether a process is in control. Processes that are in control will follow a standard distribution (fig. 43). When a frequency distribution is not symmetrical, it is said to be skewed. It may be skewed left or skewed right, depending on the placement of the mean (arithmetic average) and the mode (most frequent score) (fig. 44). Variability refers to the spread of scores away from the mean. The less the variability (more scores closer to the mean), the higher the quality.

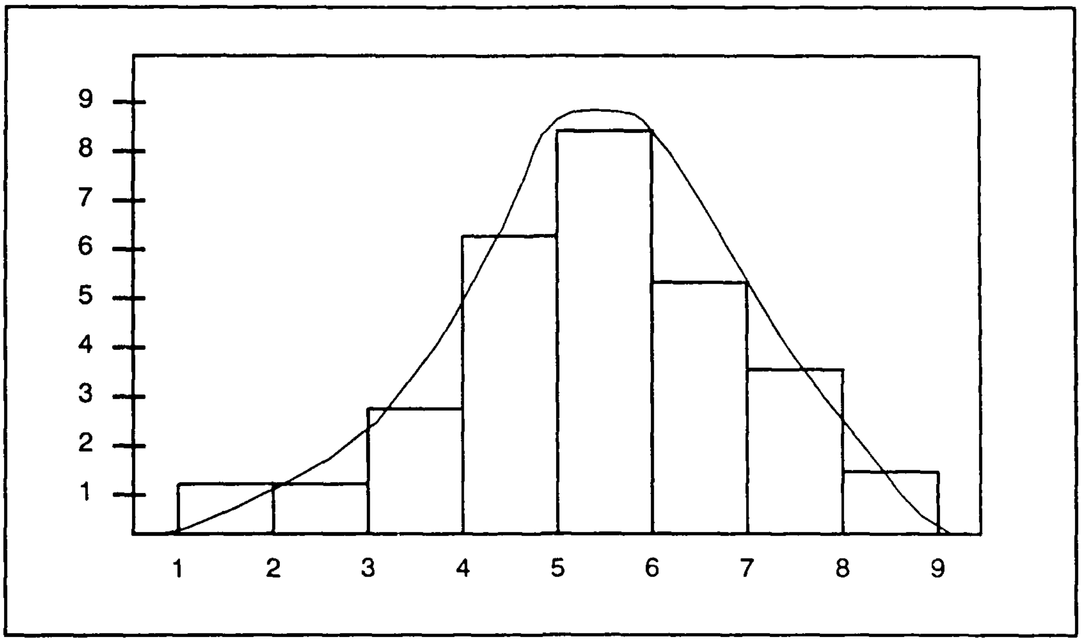


Figure 43. Histogram

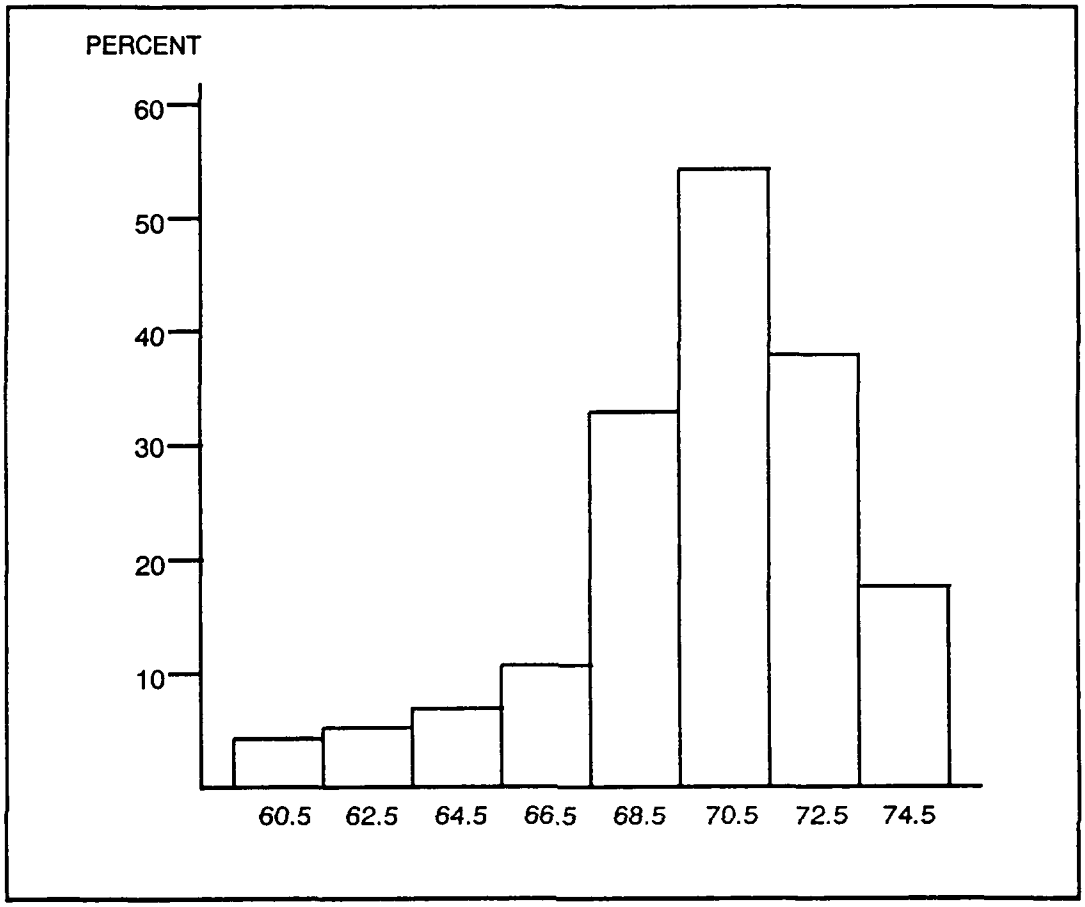


Figure 44. Histogram of College Graduation Dates for AWC Class of 1990

Histograms should be used when large amounts of data must be portrayed quickly and simply. Histograms can alert process owners that a process is not producing an acceptable distribution or verify that a process *is* producing an acceptable distribution.

- Collect the data from check sheets and arrange it as indicated in table 14. Count the data elements on the work sheet. In the example, table 14 has 159 data elements. They are represented as $N = 159$.
- Determine the range (R) of the data. $R = XL - XS$, where XL = largest score and XS = smallest score. The range in table 14 is 15 (75 – 60).
- Determine the number of data element classes (K) by using table 15. Find where the N value falls under the number of data column. Find the corresponding class in the number of classes column. In the example, the number of classes should be no less than 7 and no more than 12 ($N = 159$, $K = 7 - 12$).
- Determine the width of the classes, using the following formula (H = class width):

$H = \frac{R}{K}$ ($H = \frac{15}{7} = 2.14$; $H = \frac{15}{12} = 1.25$)

In this example, the class width should fall between 1.25 and 2.14. Select the width that best suits the purpose. Since all scores here are whole numbers, 2 is the best width.

• Next, calculate the class boundaries. Class boundaries are the beginning and ending values for the bars on the histogram. The best way to understand this is through a few examples. In our example using the data in table 14, the measurement unit is one. To figure the boundary, take half the measurement unit. In this case, half of 1 is 1/2 or .5. Thus, .5 from 60 (the lowest value) would give you a lower boundary to arrive at the upper

Table 14

Data Sheet

70	61	72	66	70	71	69	68	69	69
68	73	72	72	67	70	72	74	68	70
69	72	69	71	68	69	72	71	71	73
69	72	69	71	72	73	68	67	71	75
70	74	74	72	68	68	70	71	68	71
70	73	72	73	72	65	68	71	72	71
71	69	71	74	62	73	71	71	69	70
70	72	68	66	60	62	67	70	67	68
65	75	73	69	71	71	71	70	73	69
70	72	65	69	71	69	74	73	69	71
70	72	68	70	70	71	66	64	67	71
68	71	72	71	70	70	66	65	67	67
70	69	73	70	74	70	74	69	74	72
67	71	70	67	71	69	70	70	71	68
75	73	70	69	73	73	70	73	74	72
71	71	74	71	74	73	69	62	69	—

Table 15

Table of Classes

NUMBER OF DATA ELEMENTS (N)	NUMBER OF CLASSES (K)
UNDER 50	5 – 7
50 – 100	6 – 10
100 – 250	7 – 12
OVER 250	10 – 20

boundary (59.5 + 2 = 61.5). Repeat this process for the classes determined in step 3. To get the midpoint of each class, subtract the lower boundary from the upper boundary and divide the results by two. Then add this product to the lower boundary.

- Record the data as indicated in table 16.

Table 16

Frequency Data Sheet

CLASS	BOUNDARY	MIDPOINT	FREQUENCY
1	59.5 – 61.5	60.5	2
2	61.5 – 63.5	62.5	3
3	63.5 – 65.5	64.5	6
4	65.5 – 67.5	66.5	11
5	67.5 – 69.5	68.5	33
6	69.5 - 71.5	70.5	54
7	71.5 – 73.5	72.5	35
8	73.5 – 75.5	74.5	15

12. *Imagineering.* Imagineering is an exercise in which a team develops a flowchart that shows how a process presently works, then imagines how it could work if there were no waste. It is used to identify areas that are candidates for improvement. It is also used at the beginning of projects to plan the process. Imagineering is helpful when teams are having trouble focusing on improvements.[12]

- Create or retrieve a flowchart that describes the process currently under review.
- Develop a flowchart that shows how the process would work if there were no opportunities for failures to occur.
- Compare the two charts and determine the differences.
- Evaluate the differences.
- Seek to improve the process by targeting the differences (fig. 45).

13. *Input/Output Analysis.* Input/output analysis is a systematic method for resolving problems (fig. 46). It is used to clarify individual responsibilities, resolve conflicts, open lines of communication, and streamline inefficient processes. It should be used whenever ambiguities exist within a process. The causes may be poor communications, poorly defined process responsibilities, or undefined objectives.[13]

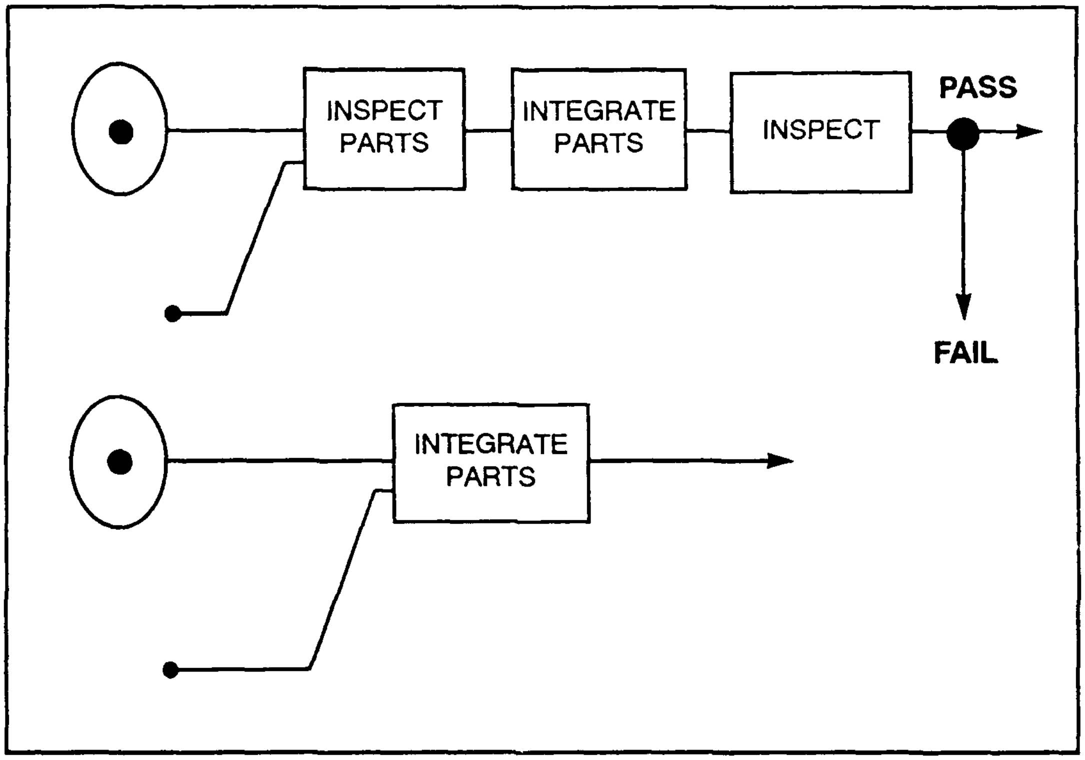
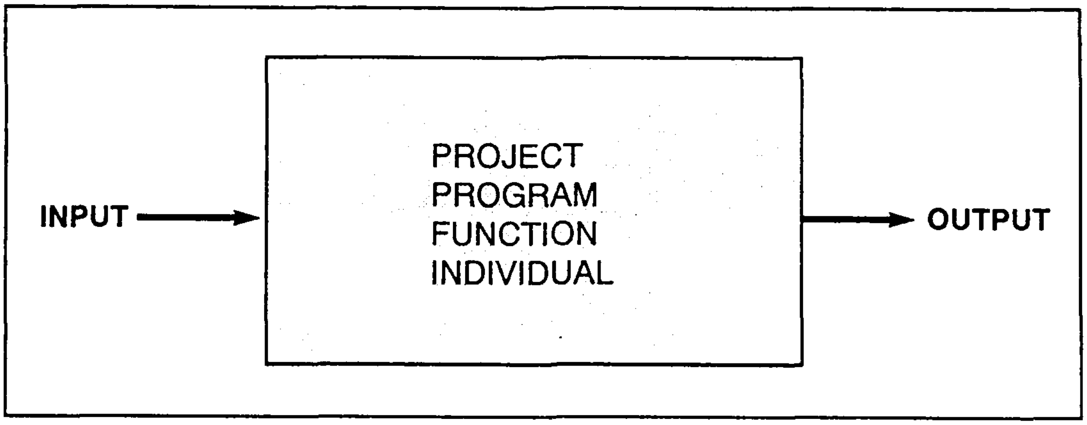


Figure 45. Imagineering

- Define the program objectives and develop a time-phased flowchart of the process.
- Define the responsibilities of all process owners, subprocess owners, customers, and suppliers.
- Define each team member's role.
- Use nominal group techniques (below) to generate and control ideas from the team.
- Review ideas against customer requirements.
- Implement ideas that support customer expectations.

14. *Matrix Chart.* Matrix charts are used to compare two groups of elements and determine any relationships between them. They should be used anytime an association must be developed between two or more sets of data.

- Identify the number of elements in each group.
- Draw enough squares on a chart to accommodate the number of elements in both groups.
- Assign the x axis to one group.
- Assign the y axis to the other.
- Review the intersections of elements on the x axis to elements on the y axis. Mark the intersections where both x and y appear.



Source: DOD 5000.51-G, "Total Quality Management Guide," final draft, vol. 1, 23 August 1989, 59.

Figure 46. Input/Output Analysis

The *y* axis in table 17 contains the months of the year, and the *x* axis contains employee names. This matrix is used to determine the relationship between requested vacation dates and employees.

Table 17

Matrix Chart

	AL	BO	SUE	SAL	JIM	SAM	BLU	JOE	MEL	BOB
JANUARY	X		X	X	X		X		X	X
FEBRUARY		X								
MARCH		X							X	
APRIL			X							
MAY										
JUNE		X		X		X		X	X	
JULY		X			X		X			X
AUGUST						X		X		
SEPTEMBER			X	X		X				

15. *Nominal Group Technique.* Nominal group technique (NGT) is a method for reducing multiple ideas to a few workable recommendations. It is a very structured group exercise in which members are limited in verbal exchange. It is similar to brainstorming, but very structured and formal.

NGT is used to develop a list of ideas or suggestions about a problem or an issue and then to narrow the list down to a workable size for action or

analysis. It is very useful when a team is new or when many team members are new to other team members. It is also very useful when a new leader takes over a process at a time when a problem must be resolved quickly; group members can participate in the decision process while getting acquainted with the new boss.

- Review the NGT procedure with the assembled team. If the announcement for the meeting is made by memo, attach a copy of the rules and state the purpose for the meeting.
- The team leader introduces the problem to the group in the form of a question (e.g., Why do we have such a bad reputation?).
- Ensure that everyone understands the problem.
- When everyone understands the problem, ask group members to write down their suggested answers. The group operates in complete silence until all team members have finished.
- List the ideas on butcher paper or a chalkboard—one idea per person—until all ideas have been listed or time has run out.
- Briefly discuss each suggestion. If there are problems in understanding an item, have the individual who suggested the item explain it.
- Revise the list to a reasonable number by asking the members to remove their less significant items from the list. Do not allow anyone to remove an item that was suggested by someone else unless the suggester agrees.
- Distribute 4 three-by-five cards to each member.
- Instruct group members to write down their top four items from the entire list, one per card, and to indicate their rank (1, 2, 3, or 4).
- After the members have made their selections, instruct them to rate the ideas on a scale of one to 10 where one represents little value and 10 represents great value. Write this number on the card and circle it.
- Total the values for each card. There will be two values: the ranking of items from one to four and the relative weight each item carries. The item with the highest weight value is selected.

16. *Opportunity Cycle.* Opportunity cycle is a structured process for finding bottlenecks, inefficiencies, and redundancies. It is initiated on a single problem, but the lessons learned are carried throughout the organization to other processes. The opportunity cycle has six phases: (1) problem selection, (2) protection, (3) analysis, (4) correction, (5) measurement, and (6) prevention. After phase 6, the cycle begins again at phase 1.[14]

Opportunity cycle identifies the problem, accommodates a temporary fix, and then works to correct the problem. Since most process bottlenecks and inhibitors occur because of administrative practices, the opportunity cycle (fig. 47) has its greatest use in the operations and administrative areas. But manufacturing areas also offer opportunities for improvement.

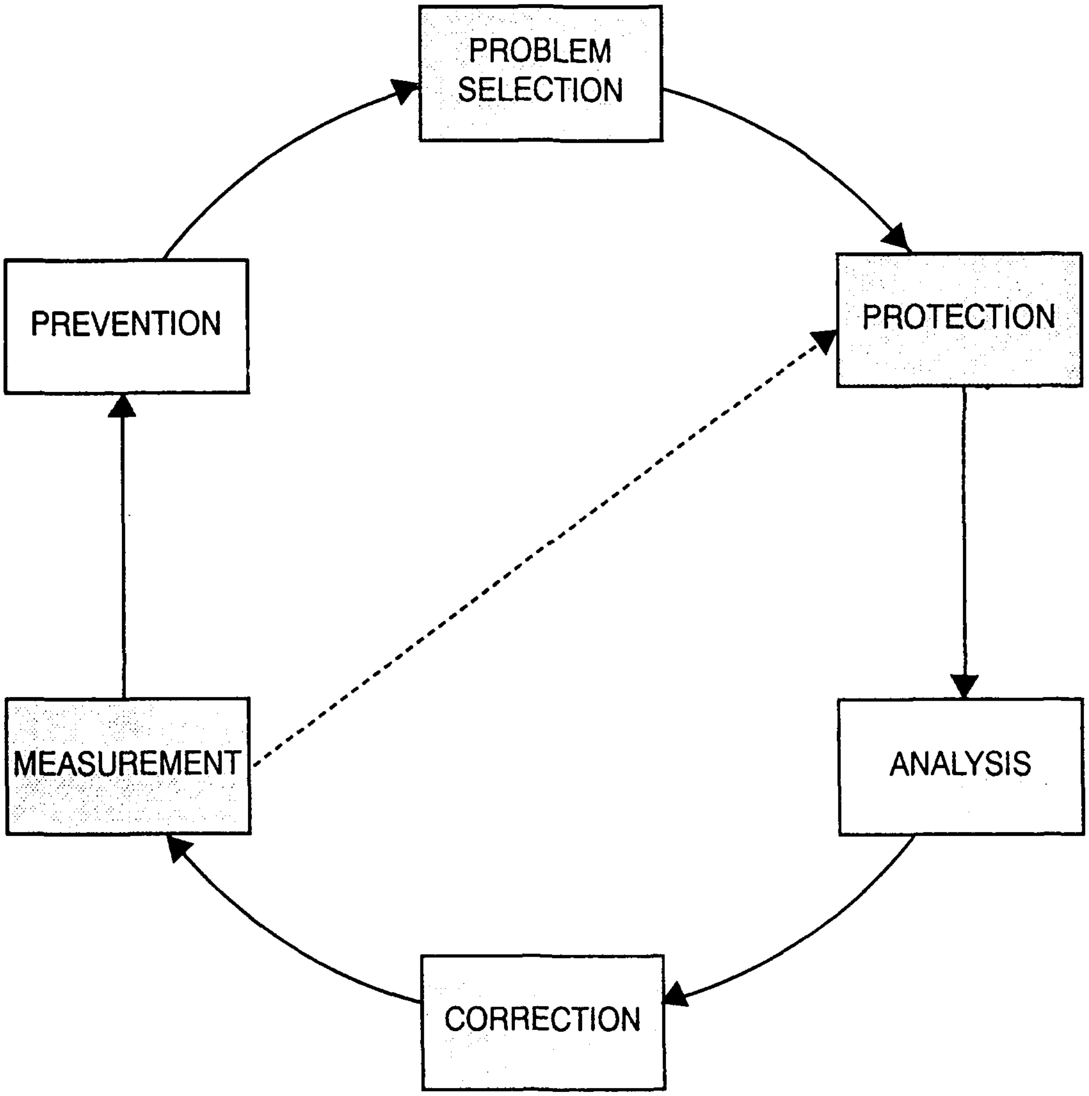
Phase 1—Problem selection.

• Identify the high-priority problems. From a list of problems, create two Pareto charts. One will reflect the impact the problems have on the customer; the other will reflect the cost of the problems.

• Based on the results of the two Pareto charts, select the problems that have the greatest impact on the customer.

Phase 2—Protection.

• Initiate a "temporary fix" immediately. This could be anything from increased surveillance to heightening awareness of the problem.



Source: Adapted from H. James Harrington, *Excellence—The IBM Way* (Milwaukee, Wis.: ASQC Quality Press, 1988), 39.

Figure 47. Opportunity Cycle

• Identify the temporary fix with some type of special marking so that everyone is aware of it and it does not become permanent.

Phase 3—Analysis.

• Analyze the process to determine where the problem arose and why. This can be done through experimentation, failure analysis, and error duplication.

• After the cause has been isolated, determine whether it is the real cause of the problem by systematically altering various aspects of it. If the problem is altered accordingly, the cause has been found.

Phase 4—Correction.

• Identify the individuals who can correct the problem (usually the people who own the process).

• After the owners accept the problem as theirs, they develop an action plan to correct the deficiency. The action plan must tell how corrective action will be initiated and how effective it will be. It must also provide a descriptive model of the corrective action.

• If the model is sufficient, the measurement phase is started. If not, the plan is sent back to the owners for additional work.

Phase 5—Measurement.

• Phase the corrective action into the process and determine whether the projected results are being achieved.

• If the correction works, phase out the temporary fix. (If not, return to phase 4.)

Phase 6—Prevention.

• Identify similar processes throughout the organization.
• Determine whether the correction would improve them.
• Select a new problem.[15]

17. *Pareto Chart.* A Pareto chart displays data by level of importance. It is based on the workings of the Italian economist Vilfredo Pareto. He developed the "Pareto principle," which states that 80 percent of the trouble comes from 20 percent of the problems. This is also referred to as the 80/20 rule.

The Pareto chart is a way of identifying the "vital few" problems that cause the bulk of unproductive costs in a process.[16] It ranks problems according to the order in which they should be worked. Whenever a process has many interrelated variables, a Pareto chart should be used to identify where to start the improvement process. Pareto charts are also useful in comparing processes before and after improvement activities.

• Identify areas that could be causing the problems. This can be done by collecting control sheets, reviewing functional reports, or gathering data from multiple sources.

• Determine which measurements will be compared and rank order them. Determine the time period for the measurement.

• Document the results on a work sheet (table 18).

• Construct a Pareto frame (fig. 48). On the left side, list the frequencies of the problems under study; on the right side, mark off the percentages they represent. Across the bottom, list the categories—in decreasing frequency—from the work sheet (fig. 49).

• Draw a bar, for each category, that equates to the frequency of occurrence as indicated on the left side. Start with the highest value on the left and work to the right. If the frequencies become too small, group the last few in a category labeled "other."

• Starting from the left, draw a line that represents the cumulative frequencies and percentages of the categories' contributions to the total problem.

Table 18

Contract Errors by Section

NUMBER OF INSPECTIONS: 1,000		
SECTION	NUMBER OF ERRORS	ERROR PERCENTAGE
A	9	8
B	22	19
C	56	49
D	6	5
E	9	7
F	2	2
G	11	10
TOTAL	115	100

18. *Perception Analysis.* Perception analysis portrays two independent elements of a product on a graph that is called a perception map. It is one of the more useful diagrams available; but because of its complexity, it is seldom seen. Perception analysis is capable of visually correlating two characteristics of many products on a single graph. It is used extensively in QFD to analyze and compare dissimilar characteristics of products. It is also used to benchmark two dissimilar characteristics of one process with the same two dissimilar characteristics of another process. Perception analysis may also be used to help develop marketing strategies.

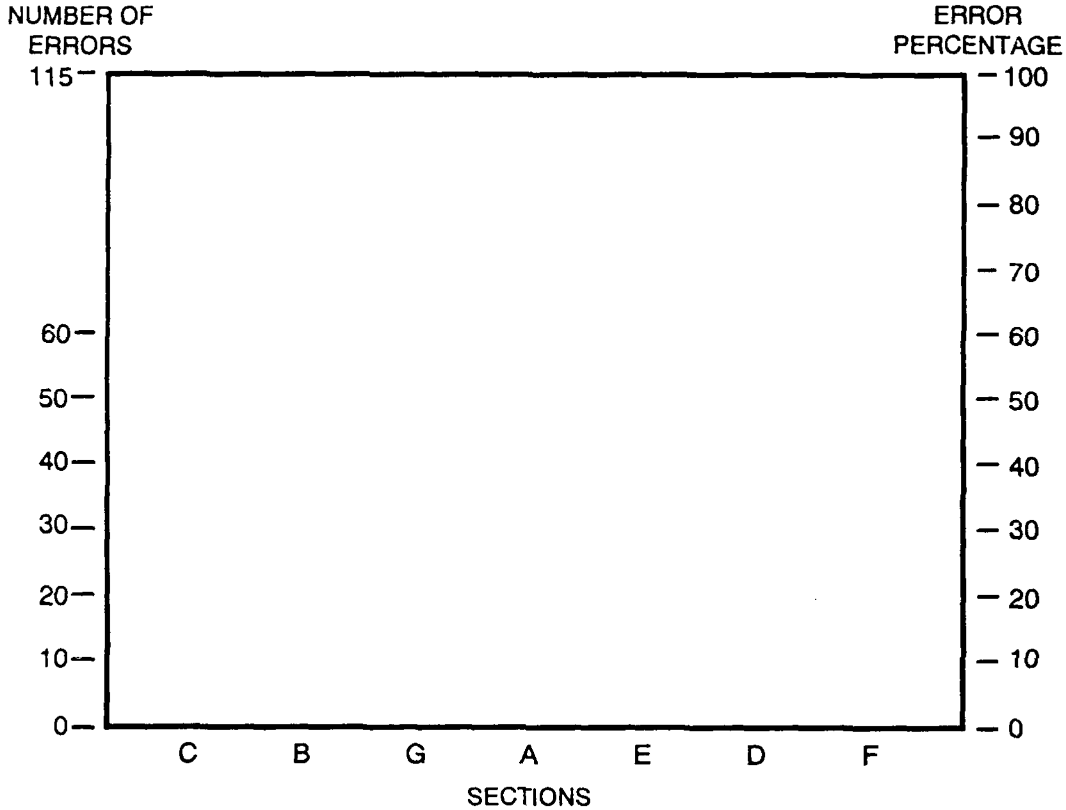


Figure 48. Pareto Frame

• Decide which two characteristics are to be measured and how they can be objectively measured. Objective measurements should equate to values from –3 to +3 (figs. 50 and 51). Develop a definition for each of the values to reduce the subjectivity to answers. The value definitions in the examples used are given below.

Aroma = (–3) nasty, (–2) unpleasant, (–1) unappealing
(1) pleasant, (2) stimulating, (3) bouquet

Flavor = (–3) nasty, (–2) odious, (–1) unpleasant
(1) pleasant, (2) sumptuous, (3) luxurious

• Develop a check sheet that lists the two characteristics and the different products (table 19).

19. *Program Evaluation and Review Technique.* Program evaluation and review technique (PERT) is a planning tool that displays a logical network of activities and the interdependency they share. The PERT network can also be used for critical path method/critical path analysis (CPM/CPA). PERT and CPM/CPA are usually used together but referred to as PERT. In its simplest form, PERT is also known as arrow diagram. It is used by most project teams to display a process or project that is going to be developed.

Table 19

Perception Map Check Sheet

BRAND	AROMA						FLAVOR					
	$\bar{3}$	$\bar{2}$	$\bar{1}$	1	2	3	$\bar{3}$	$\bar{2}$	$\bar{1}$	1	2	3
X		X					X					
M			X							X		
H				X							X	
F					X						X	
C				X						X		

Through PERT, process owners are able to develop the necessary subprocess relationships, determine the time required for each subprocess, and plan for the resources needed to accomplish the subprocesses. Each task is broken down into manageable sizes so that subprocess owners can define

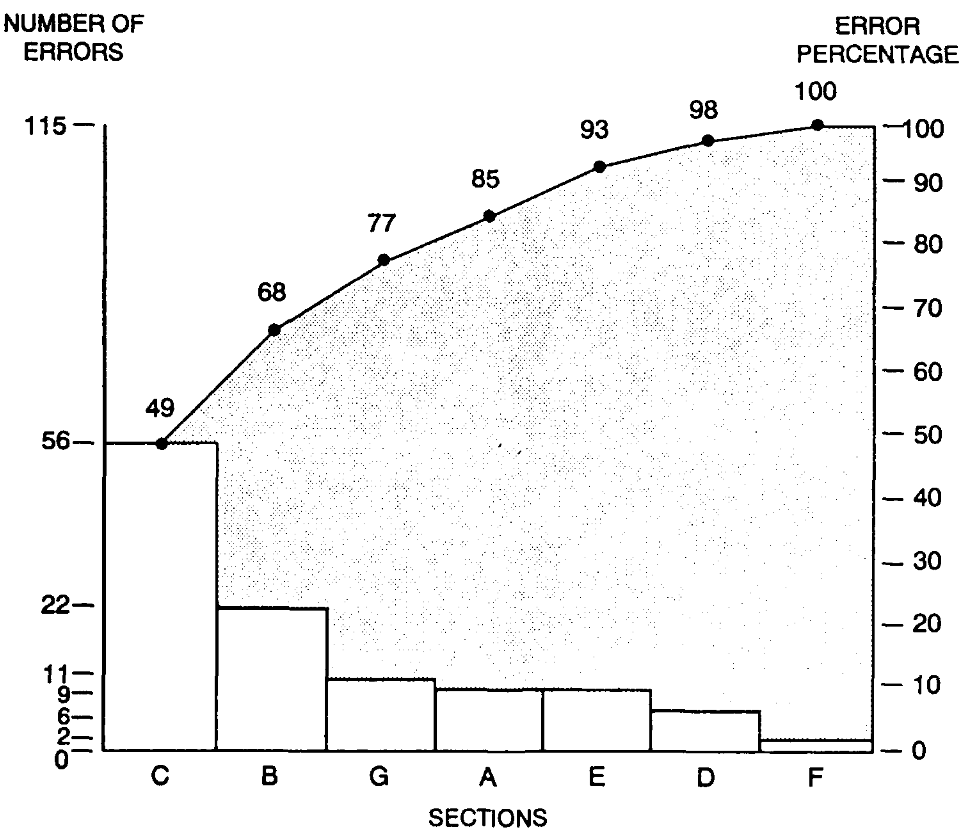


Figure 49. Pareto Diagram on Contract Errors

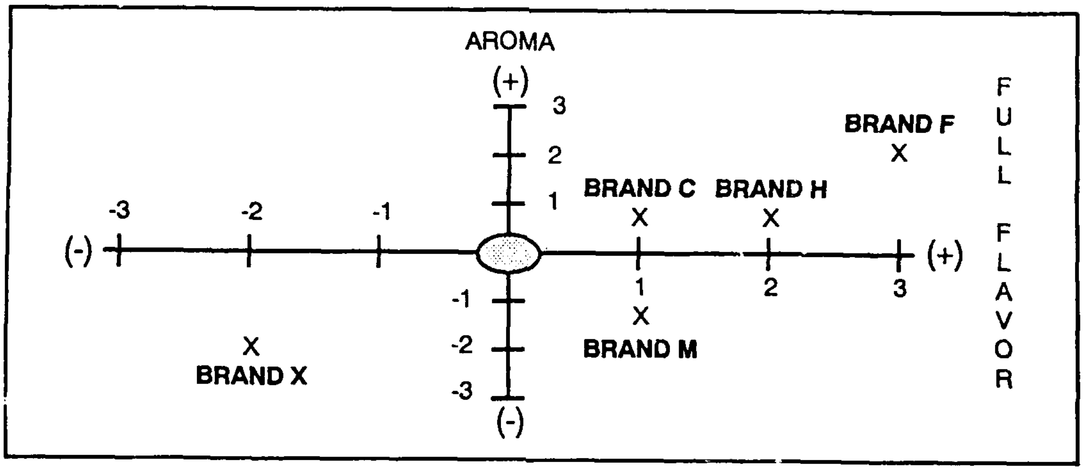


Figure 50. Perception Map Grid

their activities in detail. Each subprocess is defined; and interfaces, resources, times, and dependencies are required. The process of teardown and buildup helps to ensure that all parts of the processes are identified.

PERT should be used whenever a process or project is being developed. If the process is simple, with no more than two levels of process and no more than 10 nodes, a simple arrow diagram is probably sufficient. If there are multiple levels, many interdependencies, and more than 10 nodes, PERT will provide the level of detail needed for analysis.

• Define the goal of the project. Every project has a goal and a set of objectives. Define the objectives in simple, descriptive terms on the PERT work sheet (table 20).

• Identify the major milestones; that is, where major subprocesses come together into a measurable and definable event. You will use major

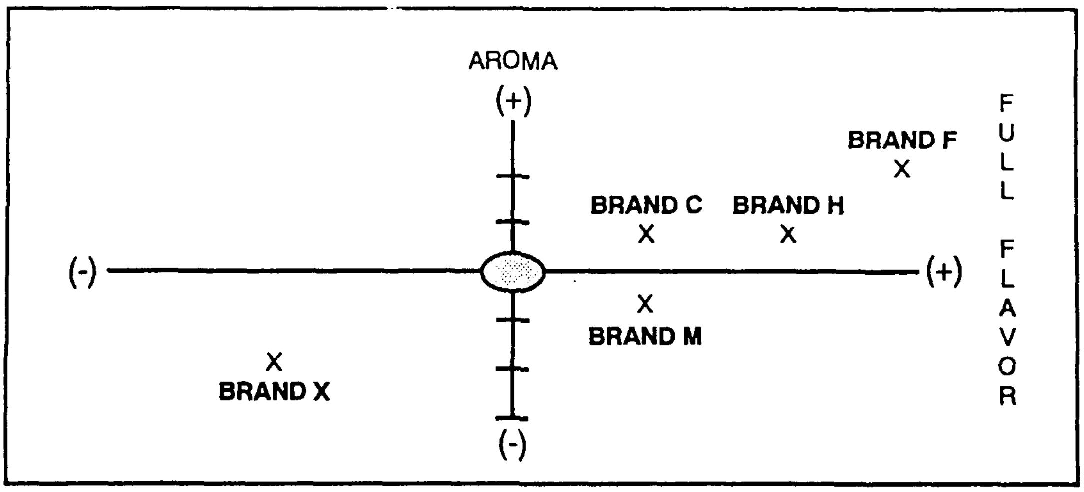


Figure 51. Perception Map

Table 20

PERT Work Sheet

TASK	PLANNED START	PLANNED FINISH	PLANNED DURATION	ACTUAL START	ACTUAL FINISH
START	1 SEP 89	1 JUL 90	MILESTONE	1 SEP 89	
ORIENTATION	1 SEP 89	10 SEP 89	10 DAYS	1 SEP 89	
RESEARCH	1 SEP 89	30 DEC 89	121 DAYS	1 SEP 89	
CHAPTER 1	1 JAN 90	30 JAN 90	30 DAYS		
CHAPTER 2	1 FEB 90	28 FEB 90	28 DAYS		
CHAPTER 3	1 MAR 90	30 MAR 90	30 DAYS		
CHAPTER 4	1 APR 90	30 APR 90	30 DAYS		
CONCLUSION	1 MAY 90	15 MAY 90	15 DAYS		
REWRITE	1 JUN 90	30 JUN 90	30 DAYS		
FINISH		1 JUL 90			

milestones in tracking the project. Document them on the PERT work sheet.

- Identify the objectives required to accomplish the milestones. Document them on the PERT work sheet.
- Identify each activity that is required to support objectives. Document the information on the PERT work sheet.
- Organize the information into logical sequences. Determine the earliest start date, latest start date, duration, and each activity's dependency. Dependencies are actions that must be accomplished in one activity before another activity can be started or completed. Use the following formula to determine the expected duration:[17]

t_a = optimistic
t_b = most likely
t_c = pessimistic
t_e = expected time

$$t_e = \frac{t_a + 4t_b + t_c}{6}$$

- After a logical sequence has been determined for all the events, identify the resources required and the times at which they will be required. Allocate the resources to each activity.
- For a simple PERT, draw out the sequence of activities, with each activity represented by an enclosure. Label the activity. Include the start

date and the duration. Draw horizontal and vertical lines connecting each activity to the activity preceding it and following it (fig. 52).

• For a complex PERT, use one of the many software programs that make the work easier and provide outstanding graphics, not to mention "what if" analysis capability.

• After the PERT chart has been developed, review the relationships between activities. Move activities around to sequence the flow of work, materials, and products to increase efficiency.

• To determine the critical path, add the duration of activities along each path. The path with the longest duration is considered the critical path. It should be highlighted with two lines between each activity. Monitor the critical path closely. Any slip along the critical path causes a slip in the entire project.

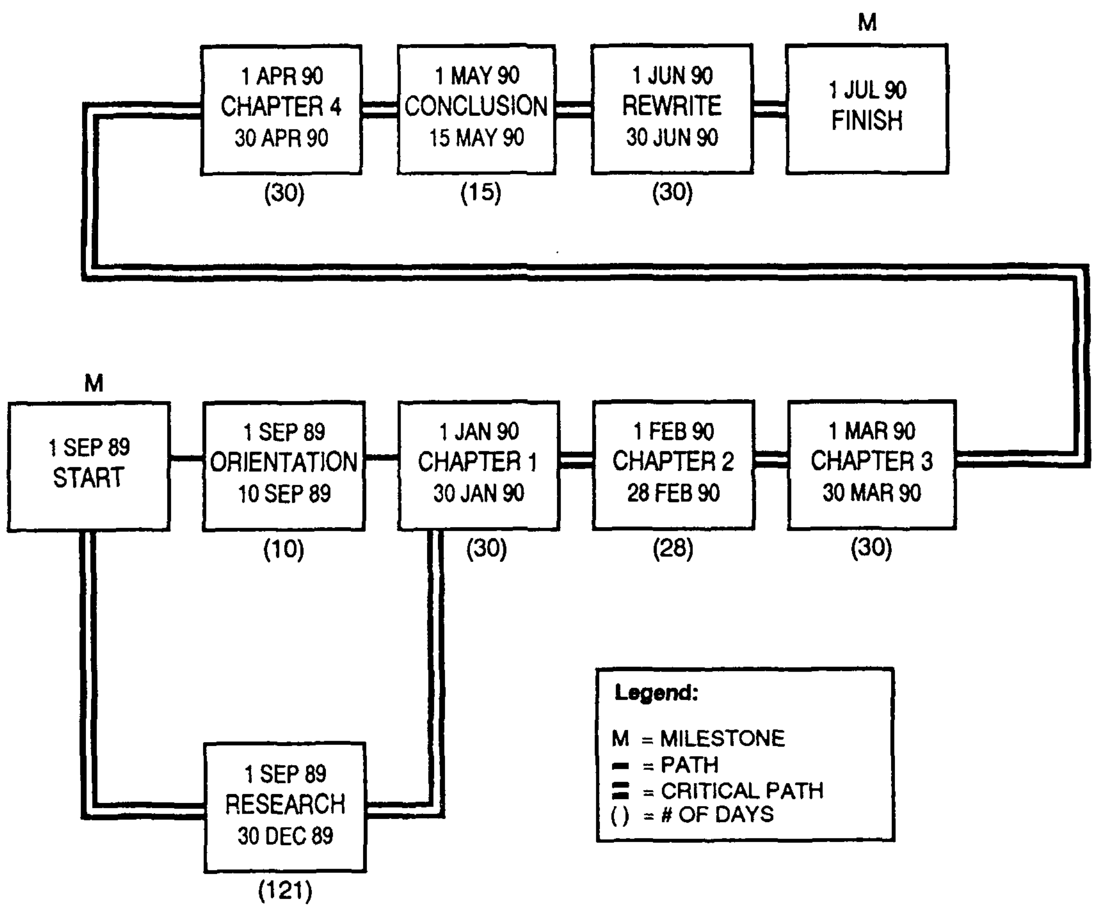


Figure 52. Program Evaluation and Review Technique

20. *Plan-Do-Check-Act.* The plan-do-check-act (PDCA) diagram (fig. 53) was created to help teams move from one step to the next in an improvement

process. The four numbered areas represent stages in improvement processing. The first phase is to plan either a particular change or a test to validate a proposed improvement. The second is to carry out the proposed change or test, and the third is to study the change and check for results. The last phase is to accept the change or reject it and start over again. These four simple steps are strong guides for improvement teams and leaders to keep in mind.[18]

PDCA is useful in keeping track of an improvement process as it moves from one phase to another. It is also used to introduce change slowly, study reactions, decide whether to move on, and to inject more change or start the process over again. It should be used with new teams and whenever change should be introduced in increments and tested. It should be a

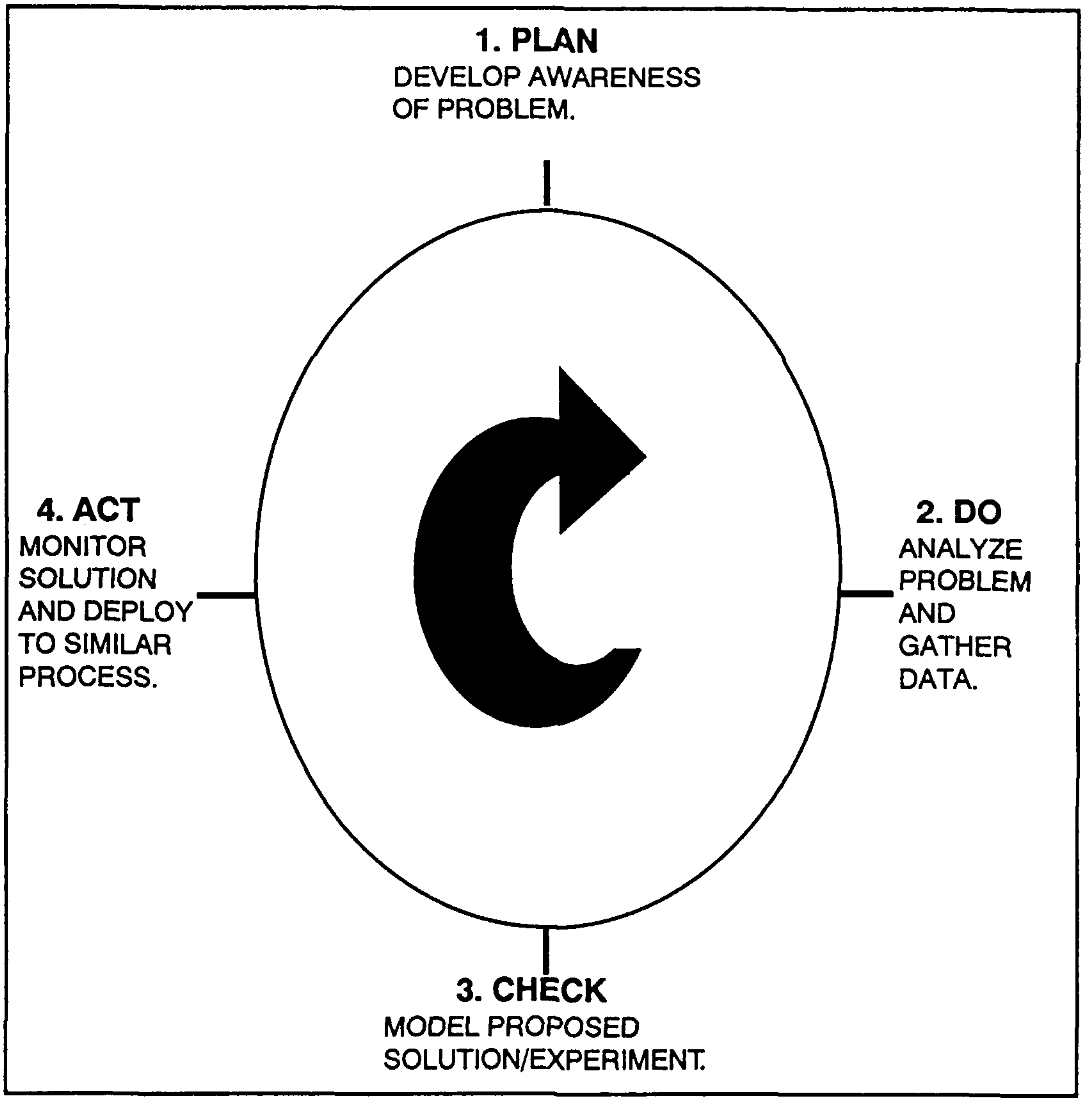


Figure 53. Plan-Do-Check-Act Cycle

fundamental part of an improvement process. Changes should be planned, carried out, studied, and then acted upon. This procedure is fundamental to the scientific approach to quality improvements.[19]

• (Plan) Develop an awareness of the problem among those leaders in the organization who can help with any resistance encountered.

• (Do) Analyze the problem and determine the appropriate solution. Determine the major changes that will have to occur if the solution is enacted. Determine who and what will be impacted by the changes and how long the changes will take to enact, test, and evaluate. Determine what will constitute success and what will constitute failure. Determine how they will be measured.

• (Check) After the above information has been gathered, model the proposed solution in a small experiment. If it is acceptable, expand it while constantly taking the critical measurements that will provide indications of success or failure.

• (Act) Continue to monitor the solution. Once the environment is stable, determine whether the solution meets the requirements for success determined in the planning phase.

• (Act) Determine what was learned from installing the solution and whether there is application to other areas in the organization. Review the changes again, standardize the process, and error-proof it by removing deficiencies.[20]

21. *Process Decision Program Chart.* The process decision program chart (PDPC) is a "what if" analytical tool. PDPC provides a structure for determining where possible failures could occur and what course of action to take if an unplanned event happens. Planners can evaluate planned activities against potential problems and structure new activities to offset the problems. PDPC should be used prior to the execution of a plan or new program, but it is also used during the execution phase. It forces the planner to model the environment to increase the likelihood that problems will be discovered and avoidance plans developed before the new process is installed (fig. 54).

PDPC comes in two types: forced connection and sequential extension. The forced connection identifies potential problems through a simulation process that leads to the undesirable activity.[21] With knowledge of the undesirable activity and the activities that lead to it, planned countermeasures can be strengthened.

• Identify the objective of the plan or program in clear, definable, and measurable terms. Place the objective in the vertical center at the far right side of the PDPC.

• Introduce the objective and explain the purpose of PDPC to the project team. The team will use either brainstorming or NGT to identify problems that could prevent reaching the objective. Explain the rules of each.

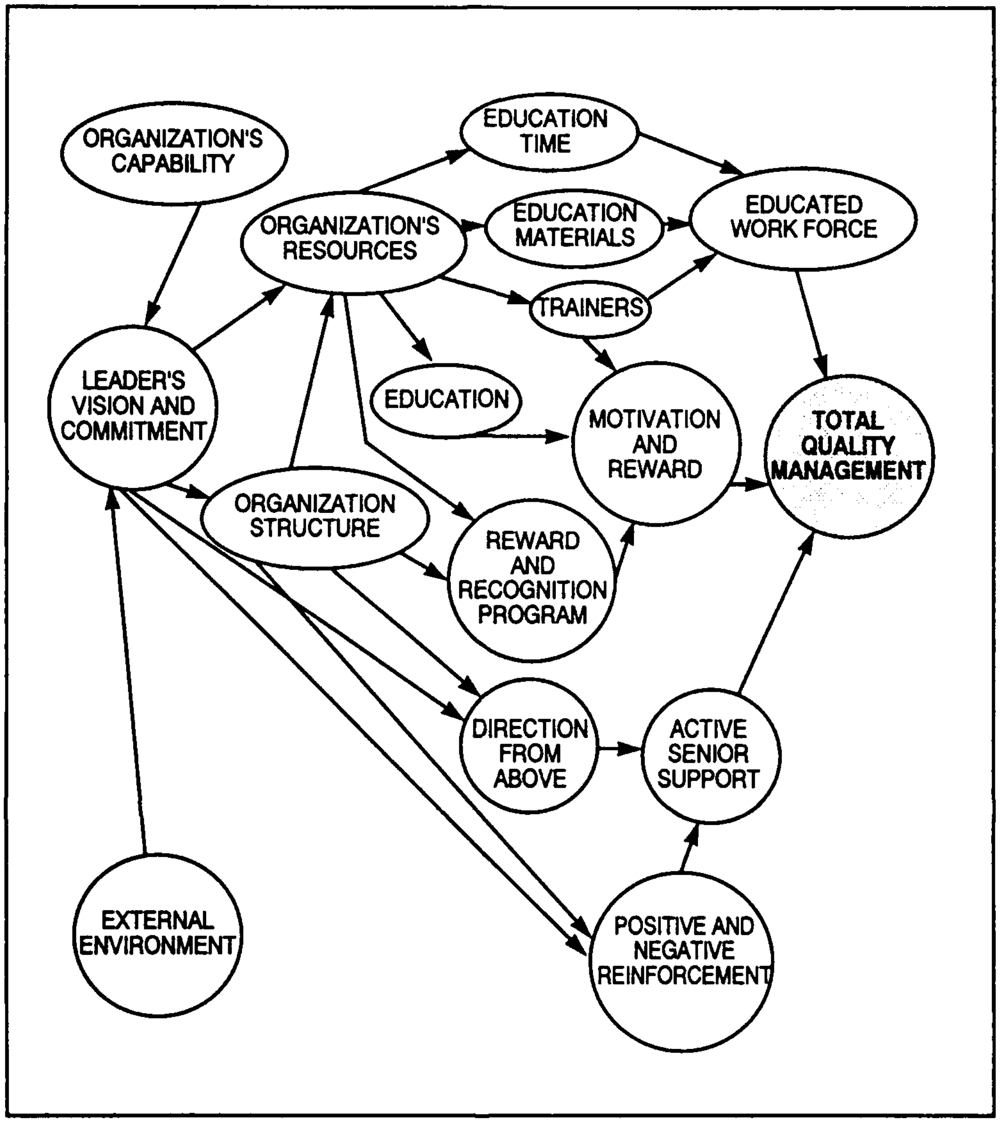


Figure 54. Sequential Process Decision Program Chart

• Program managers know where they are going and how they will get there, but they don't always plan for changes along the way. Start the process from where the project begins and map out rough milestones along its course.

• For each milestone, identify the planned, most likely, and least likely events that could occur. These events are called course activities. The most likely and planned course activities are usually the same, but there are times even with good plans when course activities are subjective guesses. Do not fill in the unknown course activity at this time. It remains blank until it becomes known, and is a reminder that something unplanned could happen at this activity.

• For each course activity, identify actions that would put the plan back on track.

• Continue this process until the objective has been reached. When finished, the PDPC should look something like the PDPC at figure 55.

• Review your plan against the PDPC and make changes where appropriate.

• Monitor the plan against the PDPC, make changes where needed, fill in the unknowns as they occur, and make changes in downstream activities as required.

Sequential extension deals with problems found while implementing the plan. Through identification of potential problems, the plan can be strengthened, thus increasing the likelihood of success.

• Identify the objective to be planned for. It should be clear, definable, and measurable.

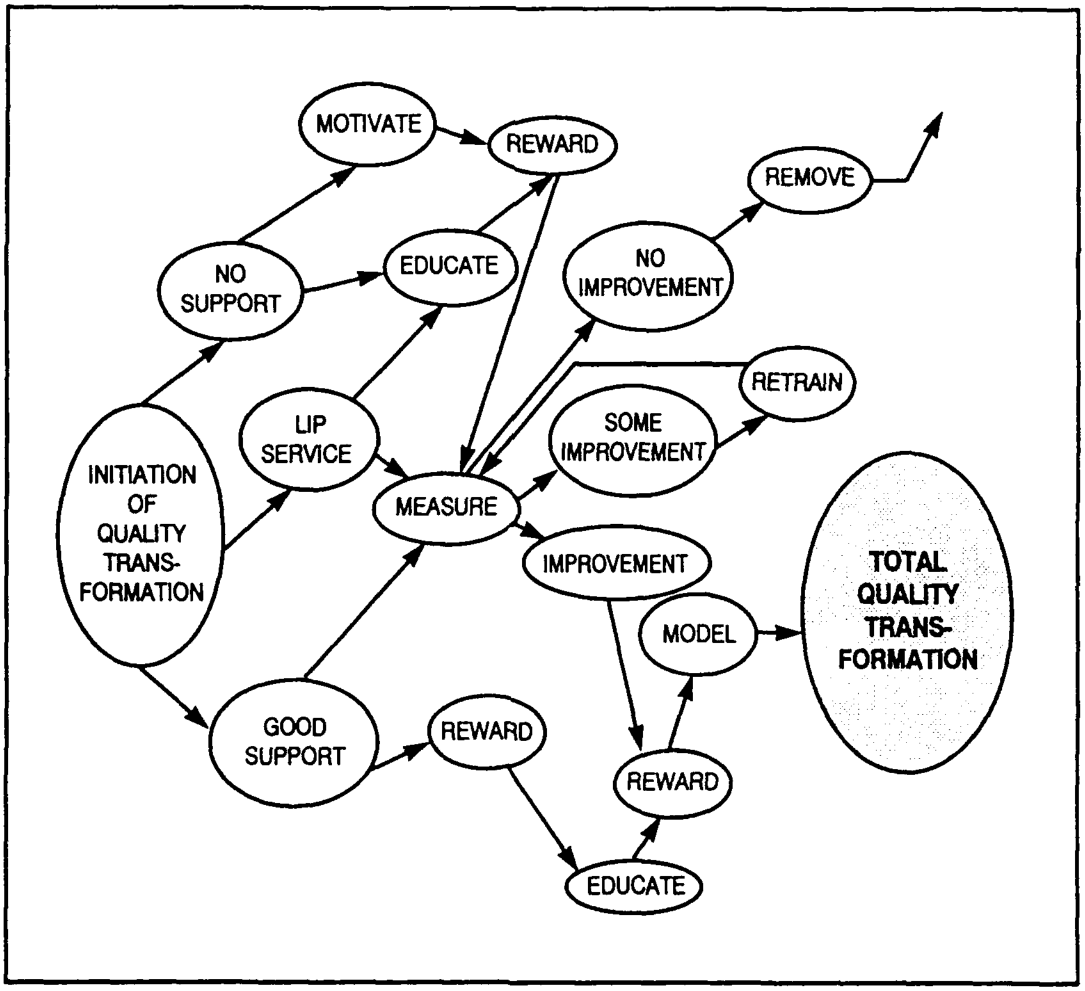


Figure 55. Forced Process Decision Program Chart

• Introduce the objective and explain the purpose of PDPC to the project team. The team will use either brainstorming or NGT to identify and develop actions to satisfy the objective.
• Identify as many desirable activities as possible and the actions that support those activities.
• Connect the activities and their supporting actions as shown in figure 54.
• Continue this process until the objective is reached.
• Review the plan against the PDPC and make changes where appropriate.
• Monitor the plan against the PDPC, make changes where needed, and make changes in downstream activities as required.

22. *Quality Function Deployment.* QFD, developed by Genichi Taguchi, was first employed at Mitsubishi's Kobe, Japan, shipyard to ensure that the "voice of the customer" was heard and understood throughout the organization.[22] QFD is a process that forces cross-functional planning and communication in the development of requirements. The process starts with the customer requirements, then identifies the design requirements to achieve the customer requirements. This "what and how" technique is carried through the entire process, from establishing the requirements to releasing the product (fig. 56). Refer to chapter 5, figures 15–22, to develop the QFD charts.

QFD is useful to ensure that all identified customer requirements are planned throughout the organization by all functional groups in the

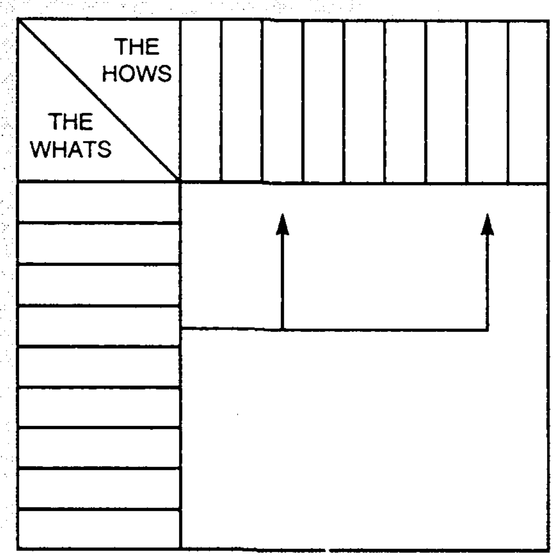


Figure 56. The What and How Matrix

organization. QFD was conceived and initially used in the manufacturing area, but it has found success as a tool for strategic planning and execution planning. Due to its structure, and consistent with the "what is wanted, how is it going to be done" approach, all requirements are tiered throughout the organization to the lowest level. In addition, implementers at these lower levels have a better understanding of what the customer wants.

QFD should be used as a mechanism that brings different elements in the organization together to plan how the organization's requirements will be met. Different requirements have different levels of interest or importance, and the implementers need to understand these differences. QFD should be used as an organizing function for all requirements and processes within an organization.

- Define the customer requirements in the customer's terms. Some experts suggest that in many cases the customer has already identified many requirements at a very detailed level. These lower-level customer requirements may need to be grouped into higher-level categories. There should be primary-, secondary-, and tertiary-level requirements. Considered the "whats," they are listed on the left in figure 57.
- Determine the design requirements and standards that are necessary to meet the customer's requirements. These come from standard operating procedures, military standards/specifications, design handbooks, and so forth.
- Develop the relationships between the customer's tertiary requirements and the design requirements. Use standard symbols that everyone in the organization will understand.
- Assign weights to these relationships. A simple one to three, or one to 10, with 10 being the strongest, is sufficient. Use the latter when there is a high degree of variation and the weights are objectively definable.

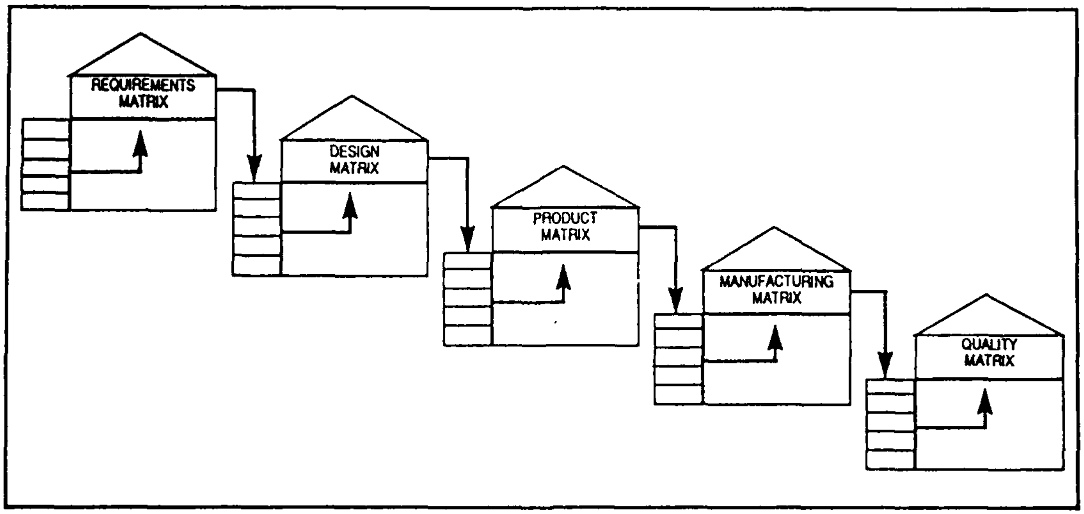


Figure 57. Quality Function Deployment Neighborhood

• Identify the risk associated with each of the design requirements. Use the same symbols and the same weight system used above.

• Develop the correlation matrix (the roof on the house) between each of the design requirements (see fig. 22, chap. 5). This is intended to identify the special elements that will require increased attention.

• Calculate the risk and the absolute and relative weights of the design requirements. The absolute weight is the sum of each design requirements column. When all absolute weights have been calculated, rank order them and enter their rank in the absolute block (fig. 20, chap. 5). The relative weight is the sum of each design requirements column times the value of the risk factor for that column. When all relative weights have been calculated, rank order them and enter the rank in the relative block.

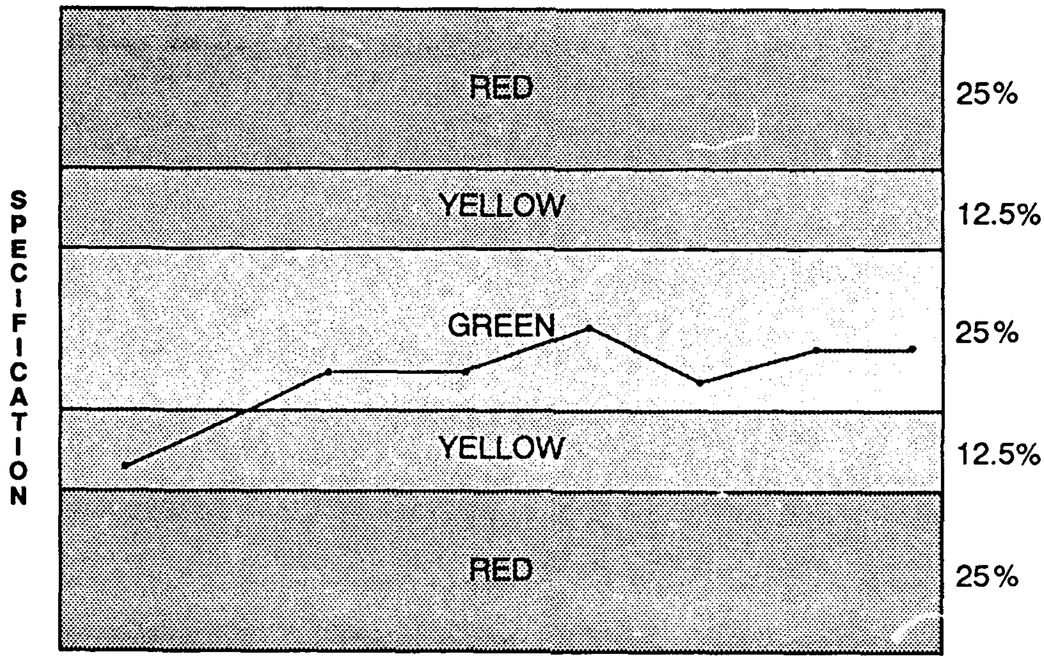
• Develop the key elements that will require special attention throughout the design process. To do this, rank the values for each of the absolute and relative weights. The key elements are the first one-third or so. An easy way to figure this is to add the relative and absolute weights in each column and select the lowest one-third as the key elements.

• Tack on any special columns, where the organization may have special advantages or disadvantages, to the side of the design matrix. This area can be used to benchmark the organization's capability against its competition or for any special category that needs attention (see fig. 22, chap. 5).

• Repeat the above process by moving the design requirements from the product characteristics area *to the customer requirements* area. Enter engineering design requirements in the vacated product characteristics area. This process is continued until each matrix is fully developed (fig. 57). When quality function deployment is used for something other than product development, the content of each subsequent matrix is dependent on its use.

23. *Rainbow Control Chart.* A rainbow control chart divides a specification tolerance into quarters and distributes the middle two quarters to the center (green and yellow, fig. 58). The remaining two quarters are allocated to the outer portions of the chart (red). Operators are directed to maintain their operations in the true center of the specification (green). The example in figure 58 represents a process that is generally within the middle 50 percent of the specification—possessing high quality and very little variability.

Rainbow control charts are very good for small preproduction and production runs, or lots that are measurable and designed so that operators have the ability to make fine adjustments and bring the process back into control. This chart should not be used if the process is not yet under control, if abnormal distribution of errors is occurring, or if the operator is not able to take measurements and make fine adjustments. It should be used when a process maintains a normal error distribution and operator



Source: Adapted from H. James Harrington, *Excellence—The IBM Way* (Milwaukee, Wis.: ASQC Quality Press, 1988), 29.

Figure 58. Rainbow Control Chart

adjustments do not lead to wide variations.[23] It can be adapted for use by operations, administration, and management.

• Measure five consecutive items from a process. If all five items are in the green, the process is considered good and the operator can move on. If any one of the five is outside the green, the operator must go back and make adjustments to bring it within tolerance. Now, make five more measurements.

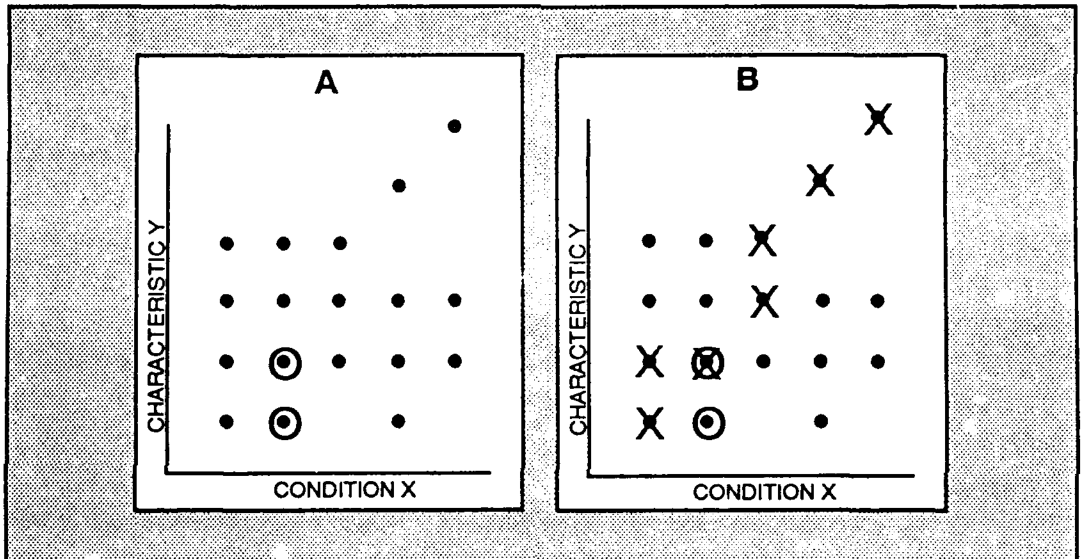
• Determine an interval rate for measurements (i.e., every five items, 10, 100, etc.). Use standard sampling techniques.

• Select two items for measurement and apply the following rules:

1. Test the first item. If it is green, keep the process constant and do not test the second item.
2. If the first item is yellow, test the second item. If the second item is yellow, stop the process and make adjustments. After start-up, apply step 1 above and test the next five items.
3. If the second item is green, continue the process.
4. If the first item is red, stop the process and return to step 1 above.[24]

• The object of precontrol is to preclude the release of poor components to the customer. Operators should be able to take the measurements and make the adjustments with little variability in the final output.

24. *Scatter Diagram and Stratification.* Scatter diagrams are visual displays of relationships between two variables. The two variables are plotted on a graph. Stratification separates elements of data by some common characteristic and then assists in determining a visual correlation. In many cases, scatter diagrams will show no correlation until the data has been stratified (fig. 59). As characteristic *y* is increased, condition *x* increases. This becomes evident only when the data is stratified (e.g., by place of manufacture). In this example, the *x*'s over certain dots represent a particular place of manufacture. (The circles represent more than one hit at the same point.)



"A" shows no correlation between characteristics and condition. When data is stratified by identifying the products made at a particular plant (with x), a correlation is evident in "B".

Figure 59. Scatter Diagram with Stratification

Scatter diagrams are useful for confirming or rejecting suspicions of relationships between sets of data. When the data are plotted in scatter diagrams, relationships that exist can be seen; and correlation, if any, can be determined if the data is stratified by the correct characteristic. Based on evidence of correlation, further tests can be performed to verify the correlation and processes can be changed to reflect the newly gained information. Even when no correlation is discovered initially, stratifying the data may lead to discoveries that were concealed by other data.

Scatter diagrams and stratification should be used to visualize cause-and-effect relationships. They should be used to view relationships before changes are made to processes and to determine if there is a relationship

between the proposed change and other elements of the process. Stratification should be used whenever possible when scatter diagraming is done. Since it is possible to discover through stratification that a relationship exists, it is also possible to find out through stratification that a relationship does not exist.

- Collect data on work sheets. Fifty paired samples are sufficient.
- Draw the graph with x as the horizontal axis and y as the vertical axis, where the x axis is the suspected cause and y axis is the effect.
- Plot the data on the chart. Where data falls on the same spot as another data point, draw a circle around the dot (and a circle around the circle if it is repeated).[25]
- Read the correlation as shown in figure 60.
- Stratify the data to determine whether a relationship exists. Screen out such characteristics as point of origin, machine, time, crew, and so forth. This can be done with x's as in figure 59, or dots can be color coded—whatever will easily identify differences between the items being tested.

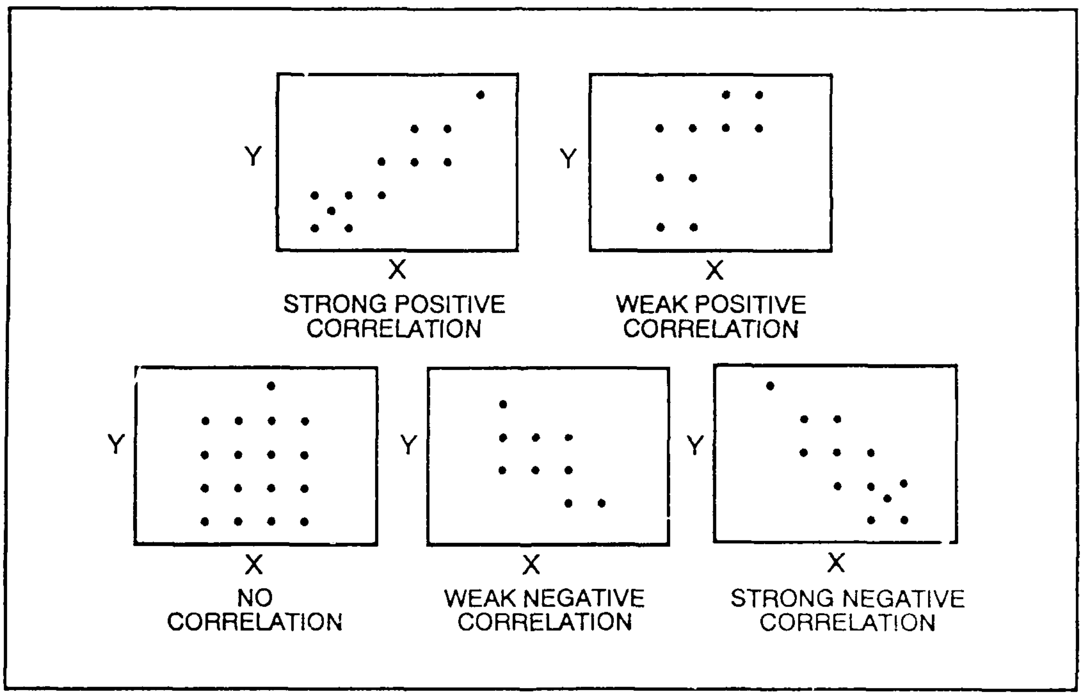


Figure 60. Interpretation of Correlation Patterns

25. *Time Management.* Time management directs workers to do what is important, not continue to waste time on the "trivial many." It is used by many senior managers and leaders to control their own time rather than being controlled by what comes across their desks. It prioritizes their work load. Using the ABC approach, categorize all work:

- A—Work that must get done to improve the organization.
- B—Work that is important but not required to satisfy a customer.
- C—Unnecessary work that wastes time and adds nothing.

Take care of A-level work immediately, then B-level work. Place all C-level work in a box. Pull it out if a mistake was made in the assignment of a priority. When two months have gone by and no one has asked for the work, throw it out!*

26. *Work Flow Analysis.* Work flow analysis (WFA) is a methodical approach to improving a process through the elimination of tasks that are unnecessary. It identifies both the preferred approach and the way the task is currently being performed. The differences are areas for elimination. WFA should be accomplished regularly on all multitask processes.

- Define the purpose, objectives, start points, major milestones, and end points of the process.
- Identify the major responsibilities of the functional organization, interfacing organizations, and any others that have a stake in the process.
- Develop an arrow chart or PERT (depending on the size of the activity).
- Have a process action team analyze the data to determine choke points, duplicative efforts, nonproductive activities, and waste.
- Develop a plan-do-check-act cycle to implement changes.

Notes

1. J. M. Juran, *Juran on Planning for Quality* (New York: Free Press, 1988), 265.

2. J. M. Juran and Frank M. Gryna, eds., *Juran's Quality Control Handbook*, 4th ed. (New York: McGraw-Hill, 1988), 24-2.

3. Ibid., 22-48.

4. Gerald Nadler and Sohozo Hibino, *Breakthrough Thinking: Why We Must Change the Way We Solve Problems, and Seven Principles to Solve This* (Rocklin, Calif.: Prima Publishing & Communications, 1990), 88, 89. *Breakthrough Thinking* is a registered trademark of Gerald Nadler and Sohozo Hibino.

5. Michael Brassard, *The Memory Jogger Plus+* (Lawrence, Mass.: G.O.A.L./QPC, 1989), 21. Use the four Ms (manpower, machines, methods, and materials) or four Ps (policies, procedures, people, and plant). *The Memory Jogger Plus+* is a registered trademark of G.O.A.L./QPC.

6. Kaoru Ishikawa, *Guide to Quality Control* (White Plains, N.Y.: Quality Resources, 1986), 61–85.

7. Juran and Gryna, 24-48, 24-49.

8. Peter R. Scholtes, *The Team Handbook: How to Use Teams to Improve Quality* (Madison, Wis.: Joiner Associates, Inc., 1988), 2-24.

9. Herbert M. Appleton, *Measuring the Cost of Quality of Business Processes* (Washington, D. C.: AIAA/ADPA/NSIA 1st National Total Quality Management Symposium, American Institute of Aeronautics and Astronautics, Inc., 1989), 200.

10. *Total Quality Improvement: A Resource Guide to Management Involvement* (Seattle: Boeing Aerospace Co., 1987), 43.

*I've been doing this for years. The only real surprise I've had is that I keep throwing out "C" boxes and no one notices!

11. M. G. Bulmer, *Principles of Statistics*, 2d ed. (Cambridge, Mass.: M.I.T. Press, 1967), 33–35.

12. *Total Quality Improvement*, 44.

13. DOD 5000.51-G, "Total Quality Management Guide," final draft, vol. 1, 23 August 1989, 59.

14. H. James Harrington, *Excellence—The IBM Way* (Milwaukee, Wis.: ASQC Quality Press, 1988), 39–40.

15. Ibid.

16. Juran and Gryna, 20-21, 20-22.

17. *Systems Engineering Management Guide* (Fort Belvoir, Va.: Defense Systems Management College, 1983), 3-3.

18. W. Edwards Deming, *Out of the Crisis* (Cambridge, Mass.: Massachusetts Institute of Technology, Center for Advanced Engineering Study, 1986), 86–90.

19. Scholtes, 5-46.

20. Ibid., 5-46, 5-47.

21. Jack B. Revelle, *The New Quality Technology* (Los Angeles: Hughes Aircraft Company, 1988), H-18, H-19.

22. Ronald M. Fortuna, "Quality Function Deployment: Taking Quality Upstream," *Target*, Winter 1987, 11–16.

23. Harrington, 29–30.

24. Ibid.

25. Ishikawa, 86–88.

Chapter 12

Continuous Improvement

Quality is never an accident; it is always the result of high intention, sincere effort, intelligent direction and skillful execution; it represents the wise choice of alternatives.

—Willa A. Foster

Continuous improvement is the culture of total quality organizations. It does not come easily or quickly; it requires time, investment, and an unfaltering commitment to respect—respect for the customer, who should always be satisfied; respect for the people within the organization, who are critical resources; and respect for quality. A total quality organization requires the commitment of every person every day and through every decision. Four principles are emphasized: constancy of purpose, commitment to quality, investment in training, and total involvement throughout the organization.

Constancy of Purpose

The root of constancy of purpose lies in the future.[1] If the leaders of an organization are motivated to provide a viable and prosperous organization five, 10, or 25 years from now, and if their actions support long-term growth rather than short-term growth for the next quarterly profit and loss statement, constancy of purpose is possible. Five critical elements must be in place in an organization if constancy of purpose is to be achieved:

1. Documented vision for the future that is understood by all.
2. Goals and objectives that support the vision.
3. Strategic and tactical plans for achieving goals and objectives.
4. A clear understanding of the leader's intent (the leaders provide guidelines for actions by subordinates throughout the organization).
5. A strong sense of urgency to get it done.

These elements make the difference between a total quality organization and countless organizations who may have "bought the book," "paid the consultant," and "declared quality number one." Constancy of purpose should be *evo*lutionary, but in American organizations it is *rev*olutionary; it requires us to change from a short-term perspective and immediate payoffs to a long-term perspective where rewards are distant and uncertain.

A Vision for the Future

We defined *vision* in chapter 6 as *the images employees have about where the organization has been, what it did well, the mistakes it made, where it is now, where improvement is needed, where it should be in the future, and how it will get there—through a common strategy, a common culture, and dedicated people.* Vision comes from the senior executive, who must understand the organization and be able to communicate the vision to the organization. This is accomplished through a slow and deliberate process that requires organizations to posture themselves for living in the long term. Five activities focus on the long term:

1. A long-term compensation system.
2. Keeping good people longer.
3. Exercising the vision.
4. Long-term measurements.
5. Talking long term.[2]

Long-Term Compensation System. A long-term compensation system is the most immediate way to get an executive officer's attention: "The organization's perspective is now long-term; make your decisions accordingly because that is how you will be rewarded." And if the organization improves, rewards follow. But in government organizations, where financial rewards are slim to none, something different must be done. Three possibilities are performance ratings, merit pay, and extended tours.

Develop a five-year plan that is consistent with the organization's vision and that assigns incremental responsibility to the individual. Performance is rated on progress toward meeting and exceeding the organization's goals. The organization must provide whatever is needed for the individual to exceed the goals. Remember the 85/15 rule.*

Merit pay should be based on successful support of the organization's vision under a five-year plan, and it should be based on the performance of the entire unit. This will increase harmony and teamwork, as individuals must work closely and rely on others for their merit awards.[3]

The standard rotation of military members to geographically different locations is two or three years. Over the past few years, however, most assignments have been extended to three or four years, and in a few cases even five years. Still, individuals have not developed long-term perspectives because they have not known the length of time they would remain on station. They maintained a short-term point of reference. Most current planning is designed to prove that the current leader is great and should be promoted. Long-term initiatives receive little support because the results will be on someone else's watch.

*A total quality organization does not use annual performance ratings because they are disruptive to team dynamics. For the time being, however, the Air Force will continue to use individual performance ratings. Nevertheless, the Air Force should be as consistent as possible with other total quality principles.

Assignment of military members in the future, especially leaders, must be for *at least* a five-year period. Leaders must know going into new positions that they will be there long enough to make a difference. Going into positions with long-term perspectives will allow leaders to accomplish long-term planning initiatives.*

Keeping Good People Longer. There is nothing more unproductive than an organization whose executives and managers spend a good part of their energy looking for a better job. The organization must create an atmosphere in which employees get more out of the long term than the short term. Promotion potential, rewards, and security must be factored into the organization and become a part of the culture. Over time, the culture can be modified through rewards for those who maintain long-term perspectives. After this cultural modification has occurred, peer pressure within the organization will continue to promote long-term perspectives.

Exercising the Vision. Never let the vision die. Don't put it on a plaque and expect everyone to work toward fulfillment. Exercise it every day through every decision made. Employees are quick to pick up subtle changes or waning support for an element of a vision. Visions should be broad enough so that they are not changed every week. In one case an individual established a vision that called for a cap on risk. After about a year, he realized that the cap was too low. Instead of mandating a change from the top, however, he allowed the need for change to bubble up from the bottom over a period of years. By the time the change was made, it had the full support of the organization and its culture.

Long-term Measurements. Take every quarterly status chart and have the data replotted on a five-year scale. Measure activities over the long term. Instead of looking at the organization through a microscope, look at it through a *macroscope*. Use the PMS toolbox to take data captured at the process levels and to look for long-term trends and conditions. When more attention is directed toward the short term than the long term, employees will redirect their attention to the short term.

Talking Long Term. As the vision is being articulated in daily activities, the long-term goal is always stressed. It is counterproductive to talk long term but act short term. A good example of this can be seen in the training function. Training is a long-term investment in a critical resource. Show an investment philosophy that matches the rhetoric. As employees accept the long-term approach of the organization, their actions will match.

Goals and Objectives

After visions are articulated and documented, goals and objectives that provide an incremental set of steps to achieve the vision must be developed. Organizations should establish long-, medium-, and short-term goals and

*This text does not cover the results that Tactical Air Command achieved under the extended tenure of Gen Wilbur L. Creech.[4] In short, General Creech has been credited with making significant accomplishments in a department that had not been noted for organizational excellence. This author believes that these results were made possible because General Creech had a vision and was allowed six and one-half years as the TAC commander to execute his vision.

objectives, linking each to some facet of the vision. The strategic planning system (SPS) provides the linkage needed between the vision and the goals and objectives established to fulfill the vision.

Just as goals and objectives are developed to break the vision down into manageable chunks, so must the goals and objectives be further divided into manageable planning chunks. Goals and objectives are tied to the operation through a five-step tactical planning process (TPP):

1. Develop annual planning goals and objectives.
2. Develop program planning analysis.
3. Establish outcome expectations.
4. Develop performance indicators.
5. Assign responsibility and establish budget.[5]

In most cases, all five steps in the TPP should be completed before functional organizations submit their programs to the tactical formulation team (TFT).

In the tactical formulation stage of the strategic planning system, which was briefly touched on in chapter 6, goals and objectives are received from functional areas. Functional organizations receive the strategy formulation document from the strategy formulation team and begin the process of developing program goals and objectives that will support the broad functional guidance. Program objectives can be started, stopped, increased, maintained, or decreased.[6]

Functional areas use these five guidelines to develop the program objectives:

1. Strong verbs are used to describe the action.
2. Only one purpose is specified for each program objective.
3. A culminating point is articulated.
4. The time frame for achievement is specified.
5. The resources required to meet the program objectives are specified in terms of people, equipment, materials, and methods (PEMM).[7]

Arrow diagrams are used to develop programs if the program objective is a simple one. Full-scale PERT charts are used for more complicated programs. Three essential elements of information are developed:

1. The activity that must be successfully completed prior to this activity.
2. PEMM.
3. This activity's requirements to satisfy the customer.

With this information known, accurate cost information can be developed to specify the financial support needed for accomplishing this program objective.

Each program objective should be measurable in terms of both progress and successful completion. Examples of outcomes include such elements as quality cost reduced by 5 percent; cost of manufacturing reduced by 17 percent; absenteeism reduced by 50 percent; and sales increased by 10 percent. As objectives are developed, they are identified at the functional

level. Later in the tactical planning process, the tactical formulation team will consolidate outcomes to validate their consistency and their support of the strategic vision.

Use the performance measurement system (PMS) toolbox to develop a measurement system that will track the program and keep it in control. Always start with quality function deployment (QFD) or, in the case of projects that go across a functional organization, strategic requirements processing (SRP).

As a final step, develop a deployment diagram and assign responsibility for each activity to either an individual or a function. Consolidate all the budget estimates against each function and develop an earned-value allocation for each function.

After the budget estimates have been consolidated, this information is incorporated in the TPP and forwarded to the tactical formulation team, after which it is acted on by the strategy formulation team (SFT). Only when the SFT approves the program do functional organizations have the authority to start, stop, increase, maintain, or decrease the activity.

Continuous improvement is achieved through the above detailed SPP because successive functional organizations are required to identify changes necessary to improve their processes and meet the strategic vision.

Strategic and Tactical Plans

Philip Crosby, in his book *Quality without Tears*, relates a charming story about a company's planning system.[8] As the story goes, Phil was looking for a company that had an excellent planning system when he found a company called Lightblue Corporation (LB). LB was considered the best in the industry. Competitors and other strategic-minded companies would hire LB's young executive staffers away from LB as soon as they were trained and able to implement a similar system in their plant.

As Crosby interviewed a senior vice president about LB's planning system, he found out that the system was quite extensive and that it required a tremendous amount of time to administer. People had to come together from all over the world to provide strategic input and to receive guidance with which they were expected to develop their tactical plans to execute the new programs.

Crosby was quite impressed with the extent of the operation. He next met with the manufacturing and quality vice presidents and found they had little involvement in the system. Then he met with a division president and found that she did not use the system but participated in developing the corporate planning system to keep the staff off her back.

After that interview Crosby had the opportunity to meet with the CEO, who told him that he didn't use the system either. If he needed something, he said, he just called and the answer was forthcoming. When asked who used the planning system, the CEO said the operating people used it to plan their work.

Crosby soon determined that the only people who really used the system were the people who administered it. The lesson to be learned here is that strategic and tactical plans must be simple and that the tools used must be those that will best meet the function's needs. When functional organizations participate in the TPP, they develop the plans they need to execute the work they do. The organization should let functional organizations use what they are comfortable with and measure them against their own plans, not the staff's plans.

Leader's Intent

Leader's intent is really the highest level of strategic planning. All other plans cascade from the leader's intent. In the Air Force, leader's intent would be called the commander's intent. The commander allows subordinate officers to operate and make decisions in a difficult, fluid, and deadly environment because they understand full well what the commander would be telling them to do if he were there.

There is no difference in principle between the commander in a battle applying deadly firepower and the leader in a less deadly business applying the strategic vision. Leaders in both cases must articulate their vision and their intent so that all understand what can be done, what cannot be done, and how much freedom one has in making decisions.

When leaders master the ability to articulate and to have subordinates comprehend their intent, a decentralized execution system can operate effectively in an organization that maintains centralized control. In such an organization, functional units will be more willing to accept responsibility, and large staffs will no longer be needed.

Continuous improvement is achieved because all members of the organization possess the knowledge of what is expected in the future, what should be applied to get there, and how to contribute to the strategic vision.

A Strong Sense of Urgency

Organizations have to be energized to move on actions quickly, resolve them, and move on to something else that needs to be fixed or improved. A total quality organization will not be able to rest because another total quality organization will quickly pass it by. This sense of urgency, as with other elements of total quality, starts with the leader of the organization. Tom Peters, in *Thriving on Chaos*, provides seven ways to put "hustle" in the organization and keep the sense of urgency energized.[9] Four of his seven ways are listed here:

1. *Eliminate the excess in the office.* Cut out the plush leather couch, the van Gogh on the wall, and the numerous executive assistants who make it too easy to stay out of touch with the organization.

2. *Follow a conservative routine.* Cut back on executive perks and accept the same amenities provided all the people. Use the local air carrier instead

of the organization's jet. See how much time is being wasted. Lead a "lean, mean, and urgent" organization by setting the example.

3. *Be excited about the product or service.* When the training manager shows his new training program, be excited about it. When the warehouseman comes up with a revised storage system, show it to every warehouse visitor. The excitement will spread like wildfire.

4. *Go to the "center of gravity."* Peters calls it the "sound of the guns," but I prefer to think of Clausewitz's "center of gravity" which, if lost, could mean sure defeat. Turning this around, customers are the center of gravity. At every level in an organization, a center of gravity can be found. If it is threatened, the leader at that level will stop everything and go to the customer's aid. Leaders should demonstrate this urgency to support the customer at all cost and on a regular basis. The message will be heard not only within your organization but also by potential customers.

Creating and supporting constancy of purpose through continuous improvement of products and services is a marathon that will provide long-term benefits to organizations that are able to develop a long-term perspective. Anything less will immediately signal a return to defective leadership.

Commitment to Quality

"Top management should publish a resolution that no one will [ever] lose their job for their contribution to quality and productivity."[10] This goes well with Deming's other strong belief that we should eliminate fear within our organizations. Fear that is based on many years of exhortations to cut cost and increase productivity works against the total quality organization until trust and respect are earned. Trust and respect can be earned through reestablishing the priorities and characteristics of existing programs within most total quality organizations.

The best way to demonstrate the organization's recent interest in total quality is to support initiatives offered by the eager and inspired. Some organizations have gone to the extreme of approving suggestions that under most conditions would never be considered. They understand that disapproving a so-so suggestion would be viewed by the workers as another example of management's not listening to them. In some such cases, organizations find ways to approve and implement these suggestions.

Just as continuous improvement must be long term, so must support for continuous improvement and total quality. Programs designed to support quality and productivity must also have a long-term perspective. Two programs that must demonstrate support for quality and productivity improvements are the reward and recognition program and the promotion and advancement program.

Reward and Recognition

These programs would include some of the following characteristics:

- Involvement by everyone in the work force. Everyone in the work force must be involved in continuous improvement, and everyone must be rewarded similarly; the rewards should not be disproportionately different.
- Understanding what the organization wants to encourage. If suggestions from the floor are important, then put significant effort and attention in that area. If it is on-time deliveries, reward that. A good place to start rewarding correct behavior is an area that is performing poorly.
- Recognize all accomplishments, the small and the large, consistent with their significance. Start with a simple note or annotation on correspondence that the work was good and appreciated. Formalize accomplishments as they get more significant. Devise special major awards to give out at regular intervals and at special activities.
- Keep the program simple. When the program becomes a chore, change it; otherwise, the workers will soon see that the organization is just going through the motions. Keep the program light, easy to manage, and unencumbered. Make it possible for every functional organization to get at least one award that is determined by that function's leader.

Promotion and Advancement

The promotion and advancement program is the most difficult to change, but it offers the greatest opportunity to alter the direction of an organization. The existing promotion and advancement program is based on the previous direction of the organization (i.e., "don't rock the boat," "if it ain't broke don't fix it," and "that's the way it was done last year"). Under such a system, the people who are now in positions to make decisions on promotions do so based on a reflection of their own success. They continue to select individuals who reflect their own beliefs, backgrounds, and styles—not the individuals who are willing to stick their necks out and buy into the total quality initiative of the organization.

There are two ways to break this cycle. First, as happens most often during hostile corporate takeovers, the entire senior staff is replaced. This method does not take into consideration the organizational culture, which can be a very powerful force.

The second way to achieve change in a promotion and advancement program is through active participation by senior executives. They can make their presence known and felt by giving supervisors and promotion boards a list of "promotable characteristics," which would include team leadership skills, competency in statistical process control techniques, advanced education in total quality techniques, and leadership in the total quality transition of their current unit.

When this information gets out to the organization, individual behavior is modified, and supervisors begin to promote according to the recommended characteristics. To ensure the new organizational direction, the

senior executive must challenge every promotion that is not consistent with the guidelines. Any wavering will suggest that the new guidelines are meaningless, and workers will fall back to old practices (that got them promoted).

Investment in Training

Is the organization investing 5 percent of salaries for training? How about even 1 percent of salaries? If 2.5 percent of payroll cost is invested in training or if $30,000 per employee is invested in a start-up operation, or if the work force is required to attend 40 hours of classroom instruction every year, the organization could be first in its field year after year. It would be able to produce superior products, and its work force would not be as transient as others.[11]

The investment a total quality organization makes in training is much like the investment a farmer makes in developing an orange orchard. In the beginning, it consumes much attention, resources, and time while providing no return. However, after three years or so, the first crop comes in, and the farmer continues to harvest oranges for many years. Training is the same type of investment. Initially, a lot of effort is focused on the training process: the requirement, the customer, the content, and the execution, all with little or no immediate return on investment.

Tom Peters's research reveals that good training programs are found in outstanding organizations. The findings are documented in detail in his book *Thriving on Chaos*.[12] They are summarized here.

1. *Extensive training is focused on skills the organization promotes and rewards.* Teach the organization's vision to each and every member. Provide the information they need in order to understand the leader's intent. Single out the elements that mark the organization as distinctive. This is the area that should get heavy initial training and attention. Across-the-board training should also be emphasized, to ensure that each worker possesses the skills required to do the job right. Remember the 85/15 rule? Training will increase the control that workers have in the organization. Good training is *owed* to good workers, not just required for them.

2. No one is identified as a short-term employee. Approach all training as career development. Invest in people today as if they will continue to be valued employees tomorrow. Remember the negative planning rule: If you plan for something negative, something negative is bound to happen. Training for the long term helps employees focus on long-term employment. Employees see the investment the organization is making in them and believe they have a future in the organization. They believe too that the organization has a future. And these two very positive results of training come in addition to an educated work force.

3. Training is continuous and ongoing. Once the organization has invested the required resources in a training system, it should be used continuously. It is too costly to turn on and off. Training should be viewed as a continuous, incremental investment, applied one coat at a time over the life of the work force. As new skills are needed, new training should be required. As individuals are promoted, training should be a condition of advancement. Training should be offered to individuals who wish to pursue a particular advancement path in the organization as a precondition for advancement consideration.

4. You get what you pay for. Before rushing out and spending the next three dividends on a training program, the organization should determine its needs and the best way to meet them. If it is determined that an in-house approach is preferred, make sure that good executives run the program. It is unfortunate, but most training departments are not run by highly respected individuals.

5. The on-the-job-training (OJT) factor. A total quality organization should already possess an organizational structure that supports OJT effectively; that is, the team structure. Teams allow leaders to work closely with the members, determine common and individual weaknesses, and improve the quality and effectiveness of the entire unit. Team leaders are in a good position to impart knowledge and experience garnered over many years of working similar problems.

6. Don't limit the training opportunities. Teach everyone statistical process control theory and application, and encourage further education. Many companies have found that teaching employees about economics, manufacturing, distribution, business strategy, reading, and writing helps them make better decisions in their daily duties. In addition, some organizations work with local universities and colleges to develop programs that prepare employees for positions in management.

7. Training is used to initiate a new program or to change the direction of an organization. Some organizations have found that the best way to initiate change is to provide training. While Phil Crosby's "zero defects day" is a celebration, this training provides useful information and education, not just celebration. Both are probably important for employees to remember a significant cultural shift.

8. Never cut training, even in the worst of times. If the organization shorts funds on training during hard times, it will tell the work force that their leaders have no confidence in the future of the organization. In fact, training should be increased during lean times. But don't wait for hard times to invest in the future—double or triple the existing training program now.

9. All training is work-force driven. Regardless of where the need for training arises, the line workers must be involved. Line workers must help determine the requirements and participate in the training. Organizations have found the best results when the work force actually leads the training with assistance from the training professional.

Some organizations have established procedures for line units to pay for their training. Remember the golden rule: He who has the gold, rules. Training departments are more willing to satisfy their customers if the customers control their existence.

10. Training is used to teach, communicate, and promote the organization's vision, culture, and strategies. A training system that has the power to get the message out and have it reinforced in a supportive environment is an ideal vehicle. As the vision is established, or as it matures and modifies over the years, training offers a fast and efficient way to get the message out to the work force. Training is also useful in reinforcing the cultural values that exist in an organization and in indoctrinating new members into the culture and values of the organization.

Training systems should not be considered as strictly one-way information transfer systems. Since trainers work close to the work force but are neither line nor management, they offer an outstanding communications opportunity. Training systems can sense changes in values, discontentment, opportunities for process change, and technological advancements. Training systems offer more potential than most capital improvement programs, and they cost far less.

Total Involvement

Total quality is such a tightly knit, interdependent philosophy that it is difficult, if not impossible, to say that one element is more important than another. But if one had to select the most important element, it would be continuous improvement. Continuous improvement provides for the flow of organizational culture, values, and work ethic.

Part of the culture brought by the continuous improvement river is total involvement. If one had to select the most significant element of continuous improvement, it would be total involvement. Total involvement is a linchpin in the continuous improvement process. It establishes the organization's norm that no one is exempt from the total quality philosophy. It supports the belief that no process is beyond the reach of total quality.

Just as it is the most significant element, total involvement is also the most fragile element. Violation will put the total quality philosophy in jeopardy. For total quality to work, there has to be an agreeable balance between what is right for all individuals and what is right for the organization. Decisions must support the customer, the worker, and the long-term goals of the organization.

When decisions violate this balance, total involvement is jeopardized because one component compromises the remaining two. When one element exempts itself from the requirement of total involvement, an imbalance tilts the total quality organization and brings into question exemptions for other elements. When this occurs, an avalanche of exemptions destroys the balance and harmony of a total quality organization.

The bottom line of the total quality philosophy is that each element (customer, work force, and organization) must continuously work to satisfy the other two elements. This requires integrity within each element and between elements. Integrity is the mortar that keeps the total quality environment together and capable of moving forward.

Notes

1. W. Edwards Deming, *Out of the Crisis* (Cambridge, Mass.: Massachusetts Institute of Technology, Center for Advanced Engineering Study, 1986), 24–26.

2. Craig R. Hickman and Michael A. Silva, *Creating Excellence: Managing Corporate Culture, Strategy, and Change in the New Age* (New York: New American Library, 1984), 240–45.

3. Only civil service employees are eligible for merit pay; uniformed employees are not. Within the Department of Defense, both civil service and uniformed employees work together and, in many cases, do the same jobs. Tying merit pay to the performance of the entire unit will force civil service employees and uniformed personnel to work together.

4. Read Thomas J. Peters and Nancy K. Austin, *A Passion for Excellence: The Leadership Difference* (New York: Random House, 1985), which chronicles the work that General W. Creech did in TAC.

5. James T. Ziegenfuss, Jr., *Designing Organizational Futures: A Systems Approach to Strategic Planning with Cases for Public and Non-Profit Organizations* (Springfield, Ill.: C. C. Thomas, 1989), 129–35.

6. Ibid., 130.

7. P. H. Rossi and Howard E. Freeman, *Evaluation: A Systematic Approach*, 2d ed. (Beverly Hills, Calif.: Sage Publications, 1982), 59.

8. Philip B. Crosby, *Quality without Tears: The Art of Hassle-Free Management* (New York: McGraw-Hill, 1984), 25–35.

9. Tom Peters, *Thriving on Chaos: Handbook for a Management Revolution* (New York: Alfred A. Knopf, 1987), 473–75.

10. Deming, 26.

11. Peters, 323–25.

12. Ibid., 326–28.

Chapter 13

Direction/Feedback Loop

Running an organization without a direction and feedback loop is much like winking at a girl in the dark. You know what you're doing, but nobody else does.

—Stewart Britt

Two-directional, intelligible, and timely information is critical to any organization—especially an organization that is going through a total quality transformation. Information about the direction the organization is to move in must be communicated to the working units if it is to be acted upon. And if the information arrives too late, is encumbered with "bureaucratese," or is wrong, the organization will soon fail.

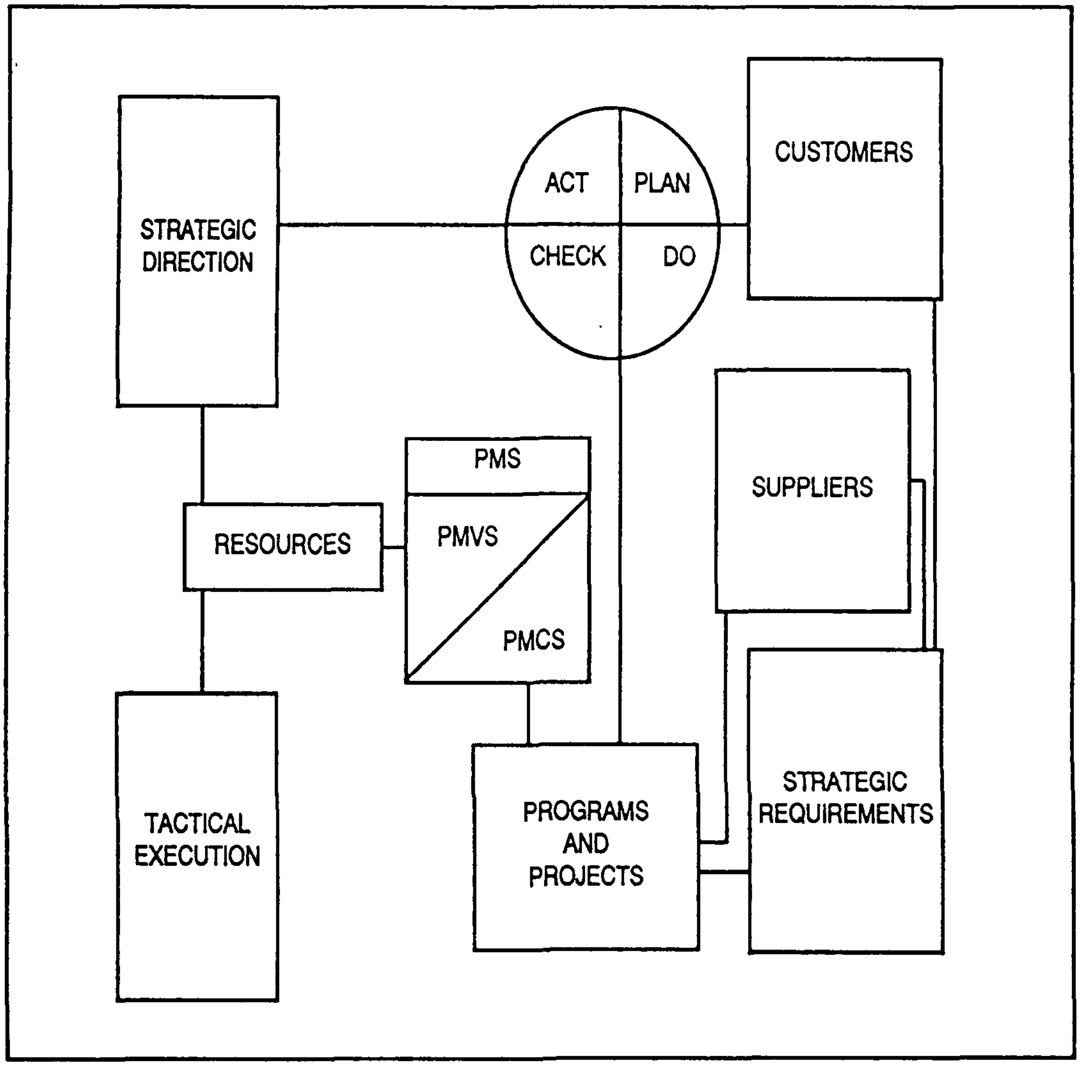
Total quality organizations establish a system that effectively passes senior direction to functional units. The system looks at the way in which information is being received and applied, and at any problems/concerns that lower-level teams may have. The system employs a mix of formal and informal communication methods. At the same time that it carries direction and feedback information from units to the organization's leaders, the system is able to receive and pass information to all other elements of the organization.

Figure 61 represents the loop that total quality organizations use to provide direction from the senior level (strategic) of the organization to the tactical level (execution). As information is disseminated, it passes through elements in which it may be converted, combined with existing information, or passed on to other elements. The direction/feedback loop (DFL) continuously distributes information. It is the cardiovascular system of the organization.

Comprehensive Dimensions of Feedback

Direction and feedback share a common communications link and a common format. Direction and feedback information can be categorized according to the following 14 comprehensive dimensions of feedback, which were developed by Robert D. Pritchard and others.

1. *Positive versus Negative.* This dimension has three permutations: positive alone, negative alone, or positive and negative presented together. This dimension deals directly with the correctness of the behavior of



Source: Robert D. Pritchard et al., *Enhancing Productivity through Feedback and Goal Setting* (Brooks AFB, Tex.: Manpower and Personnel Division, Human Resources Laboratory, July 1981), AFHRL-TR-81-7.

Figure 61. Direction/Feedback Loop

interest. If the behavior is correct, positive feedback is given. If it is incorrect, negative feedback is given. If we are dealing with positive alone or negative alone, then feedback speaks only to correct or incorrect behavior, not both.

2. *Timing of Feedback.* This dimension refers to the time that elapses between the performance of a task and the presentation of feedback. This elapsed time might vary from a long span of months or years, to a situation where feedback is available during, and immediately after, performance.

3. *Specificity.* Variation along this dimension concerns the nature of the behaviors on which feedback is given. The extremes of specificity would

range from a single evaluation of a person's total role to feedback on the smallest task-relevant act in which the person engages.

4. *Evaluative-Nonevaluative.* Evaluative feedback is feedback given by some powerful other in the organization. It clearly implies that the powerful other has evaluated the performance of the person. Nonevaluative feedback does not include this formalized evaluation by another person. Nonevaluative feedback typically would come from mechanical sources that do not involve another person.

5. *Absolute-Comparative.* Absolute feedback is information about a person's own performance only. Under comparative conditions, individuals would know their own performance levels as well as how their group compares with some other group.

6. *External-Internal.* External feedback is information which comes from a source external to the performer. This source could be another person or some mechanical device (e.g., a computer). Internal feedback refers to information which is based on a person's own experience with the task.

7. *Personal-Impersonal.* This dimension is concerned with the level of personal contact between the performer and the source of feedback. Face-to-face oral feedback from the supervisor would be highly personal, while a self-obtained computer printout outlining performance would be highly impersonal.

8. *Power of Source.* Power here is defined in terms of the ability of the source to control the individual's rewards. A high-power source would control pay raises, promotion, or social rewards. A low-power source, conversely, would control no rewards.

9. *Schedule of Feedback.* This dimension basically reflects the reinforcement schedule of the feedback. Examples of such schedules would include continuous (after every response), fixed interval (weekly, yearly), and variable interval (at different points around some average length of time).

10. *Group versus Individual.* This dimension concerns whether the feedback presented deals with individuals alone or with the entire work group. For example, information about the progress of a given group project may tell the individuals very little about their own behavior.

11. *Comprehensiveness.* This dimension is defined as the percentage of the role covered by the feedback. If the feedback dealt with only one aspect of a complex job, it would be low in comprehensiveness.

12. *Formal-Informal.* Feedback along this dimension concerns whether or not the individual has an expectation of receiving feedback prior to the feedback encounter. An annual performance appraisal interview would be an example of formal feedback. Informal feedback is more random in nature and would not be "expected."

13. *Public-Private.* This dimension refers to whether feedback is given to the individual alone or in the presence of others. These others would most generally be members of the individual's work group.

14. *Accuracy.* Accuracy refers to the validity of the information; that is, the extent to which the information given to the person validly reflects the true state or nature of his or her performance.[1]

These 14 dimensions must be taken into consideration to maximize DFL's value in improving the individual and the process. In total quality organizations, multifunctional teams can receive feedback and use it as individuals would.

The direction/feedback loop is comprised of nine major elements. They are reviewed below in terms of input, information usage, information selection, and feedback. Each element of DFL will be reviewed. No element is superior or subordinate to another, and the order of review does not indicate any precedence. Each channel (the line from one element to another) will be reviewed. As the review gets closer to the end of the nine elements, some channels discussed earlier will have already been covered. For example, when strategic direction is described, tactical execution, customers, resources, and the Shewhart Cycle are reviewed. When the customers are described, strategic vision will have already been covered.

Strategic Direction

Strategic direction comes from the organization's vision, articulated through a series of directives that comprise the annual assessment. The strategic planning system (SPS) administers the strategic direction through goals, objectives, and the budget.

Four key direction and feedback links are established from the strategic direction element, the first two of which are tactical execution and resources. It is through this linkage that direction is provided and feedback is received. Depending on the feedback, required resources are allocated or adjustments are made.

The third link is to and from the customer. This linkage is through market analysis to assess customer interfaces, organization representatives, and in-plant representatives. An electronic link between the organization's computer systems can also provide real-time information on distribution and receiving. Five conditions should be present in any system intended to pass information to customers and receive feedback from customers.

1. The means to identify, document, understand, and verify customer requirements.
2. The means to validate design information with the customer before additional time and resources are committed.
3. The means to measure and control all processes that contribute to the customer's product expectations.
4. The means to timely correct deficiencies identified by the customer.

5. Involvement and support of both strategic and tactical levels of both organizations.

The fourth link is the Shewhart Cycle. The TQM elements of continuous improvement process (CIP), mission analysis improvement cycle (MAIC), and organization provide continuous information through the Shewhart Cycle to the strategic level of the organization (strategic direction) through process improvement teams, MAIC results, and internal process improvement model (IPIM) results. In each case, when the strategic level of the organization takes an active part in these process-improvement schemes, timely direction can be provided and feedback can be received on the general health and fitness of the organization. This information can be used to modify, amplify, or initiate new strategic direction.

Direction and feedback from the strategic level will normally flow from the highest sources of power in the organization. It will be nonevaluative, positive, negative, positive and negative, directed toward groups, public, and accurate. Increased effectiveness can be achieved when direction/feedback from the strategic level is personal, public, continuous, and highly specific.

Tactical Execution

Tactical execution is the province of middle management. It receives its authority through linkage established at the strategic level. Middle management's authority is in the form of resources—that is, people, facilities, equipment, time, and funding. The SPS facilitates this linkage through goals, objectives, and programs. Goals and objectives are road maps to future improvements; programs and projects are the means by which the tactical element moves the organization in the strategic direction.

Linkage established through the SPS provides sensory information on the execution side of the organization. This information is critical to the strategic element for planning future programs and direction. The link provides information on health and morale, problems with the system, potential strategic direction, and suggestions of areas in which the organization should concentrate future activities.

The tactical system establishes linkage through the resources element to all other elements in the DFL. Without resources, the organization would cease to exist. For that reason, the linkage established from the tactical execution elements is most critical in programs and projects. Information provided through this linkage includes time and money, performance measurement, process improvements, and requirements. All this information is used to control and improve the tactical execution of strategic direction.

Direction and feedback from the tactical element should address both positive and negative findings. It should be timely and specific, it should

come from a power source that is external to the group, and it should be given on a variable basis. It should address group performance, and it should be public for positive feedback, private for negative feedback. It should include both formal and informal information. Each PAT should receive formal, comprehensive feedback on a regular basis. When processes fall out of control, PATs should receive immediate feedback.

Resources

Three links are established from resources. The first two are strategic direction and tactical execution. Resources provide information to both elements, but the fidelity of the information is greater for the tactical execution elements.

Resources are the means by which a total quality organization executes the strategic direction. Resources include people, funding, equipment, facilities, and time. Resources are the means by which all activities occur in a total quality organization. Without resources, programs and projects will not happen, customer requirements will not be satisfied, and the organization's strategic direction will never be realized. Because of the vital importance of the resources element, it acts as the bridge between the strategic and tactical elements of the organization. Direction/feedback systems must recognize the uniqueness of the resources element and reflect as much in the signals that go to or originate from it. Direction/feedback is immediate, very specific, absolute as it relates to a particular process, and external. In addition, direction and feedback are generally impersonal, identified by process or process owner, and private, and should be based on the most accurate information available. The entire execution element depends on direction and feedback.

The third link from resources is the PMS, which provides measurement data on all activities in the organization to the strategic and tactical levels. The information received through PMS is used to improve and control the managerial elements of the organization—by some estimates, about 80 percent of the organization. Management participation in performance measurement is very important; it demonstrates commitment to the process. In some organizations the president, along with the organization's senior functional directors, initiates the audit.

Performance Measurement System

The PMS makes it possible to control and improve all activities in the organization. It has linkage to resources and to programs and projects. If improvement in a process is to be ensured, performance must first be measured. PMS's two levels—PMCS and PMVS—take inputs from all

elements of DFL and provide feedback through the same channels to process owners for improving and controlling their processes.

As programs and projects are established, the tactical system establishes PMCS criteria to maintain process control. Feedback is provided to the tactical element through completed check sheets, process-owner inspection results, and error reports generated from other internal customers. Such feedback provides information for management to adjust the system and reduce variation problems.

The PMVS provides feedback to the strategic and tactical elements by identifying system problems, unsatisfied customer requirements, or areas where additional training may be needed. PMVS provides a weather vane of the organization's health by auditing its processes. It identifies changes in work habits, supplier product quality, and organizational malaise. The strategic and tactical elements provide direction to the DFL, and they reinforce areas that are important to management through audits, rewards, and recognition.

The PMS works very closely with resources to provide a bridge to programs and projects. Direction and feedback are immediate, impersonal, accurate, and comprehensive.

Programs and Projects

Programs and projects are the means by which strategic direction is executed through the tactical element of the organization. A significant difference between the DFL model and conventional organizational models is that DFL programs and projects are not directly under the tactical element; they are subordinated under resources and PMS. Any changes made to programs and projects must first go through resources and PMS. This maintains balance in the organization.

The intent of this arrangement is to ensure that direction is tempered by the budget authority in executing new or revised activities—and the PMS can test potential changes to the system before they are made. This is critical for keeping systems in control. Too often, changes initiated by management (strategic or tactical) cause havoc to the system because the potential impact of their direction is not understood before they are implemented.

Feedback from programs and projects takes into consideration the information being provided from customers and suppliers. The programs and projects element is the sole receiver of this information in a total quality organization. It is this element's responsibility to interpret and process customer requirements and to integrate that information with the appropriate programs and projects. As this information is refined in the organization, it goes through the Shewhart Cycle, PMS, and resources. These elements must act on the information where it affects their processes

and provide feedback if change may cause an alteration in a controlled system.

The programs and projects element provides immediate direction. Its feedback covers both positive and negative findings and can be either formal or informal. It is sometimes evaluative, sometimes nonevaluative, but it should always be very specific. It has the greatest opportunity to make significant improvement in quality and productivity through the use of goals and objectives. When direction and feedback are combined with a goal-setting plan, the greatest improvements are realized.

Shewhart Cycle

The Shewhart Cycle (also known as the Deming Cycle or PDCA Cycle) is part of the continuous improvement process in a total quality organization. In DFL, the Shewhart Cycle reviews activities in the organization against customer requirements, internal processes, and external inputs. The first stage of the review is to determine the opportunity for improvements, define the opportunity, and develop a theory. The next stage tests the theory within the existing environment. The results of the test are then observed. If the test is successful, the theory is applied across the process or organization.

Direction to do a Shewhart Cycle is not formalized in the organization; rather, it is part of the culture which the strategic and tactical elements encourage and reward. Formalization occurs in such TQM elements as CIP, MAIC, IPIM, and the element organization. Once the philosophy of continuous improvement is established in the total quality organization, every process owner, manager, and senior leader looks for ways to improve the organization. Feedback is very important in this element, for it helps to identify potential opportunities and it provides encouragement and recognition for successful efforts.

Three elements provide information to the Shewhart Cycle: PMS, customers, and programs and projects. PMS provides continuous data input to the Shewhart Cycle through formal and specific task-relevant information. This information can be comparative or absolute as it relates to one process. Information is forwarded either as routine information that is collected, stored, and analyzed as group data with no particular improvement opportunity known at the time, or as priority information from a particular process that is analyzed with a specific opportunity for improvement in mind. In either case, PMS information should provide an opportunity to apply statistical applications for improvement.

Customers also provide direction and feedback to the organization. Direction provided by customers comes in the form of strategic requirements, purchase orders, and other forms of solicitation. Feedback is received in the form of questionnaires, inquiries, complaints, and, in the worst form, order cancellations. Both direction and feedback must be

reviewed by the total quality organization as "the voice of the customer" to be reckoned with and satisfied at all cost. The singular importance of the customer's voice must be integrated throughout the direction/feedback loop.

The customer's voice is input to the Shewhart Cycle, which looks for new opportunities to better satisfy expectations and to receive feedback on past performance. Feedback on past failures should be acted upon immediately. The organization must determine why the product is not meeting the customer's expectations. A thorough review of present requirements includes a review of the PMS and a review of each process that has the potential to affect customer requirements. The problem is then corrected, and new processes are installed to ensure that it is not repeated. This process goes on continuously in a total quality organization.

There are times when the remedies to customer problems are beyond the authority of the tactical element. In those cases, the direct involvement of the customer with the strategic element is imperative. The strategic element has the authority to allocate or redirect whatever resources are needed to correct the discrepancies. When the resources are not available to correct the customer's loss of satisfaction, the strategic and tactical elements should work with the customer to come to a mutually agreeable remedy. The tactical element's workers must know that the customer's expectations are being changed, not ignored or glossed over. In many cases, workers have the best solutions to the problem. Therefore, the organization should be properly structured to accept worker-inspired solutions. One such structure allows workers and customers to solve problems together. They look for opportunities to achieve satisfaction and realize expectations.

Feedback provided to the organization includes both positive and negative findings, and it is given on a regular basis. The specificity of the information is dependent on the information source. If the information is internal to the customer's organization, it should be very specific. However, if information is being passed through many intermediaries (warranty complaints from the customer's customers, for example), the information is likely to be sketchy and nonspecific. In these cases, it is important to get information that is as accurate as possible even if it must be obtained from the ultimate customer. Information accuracy and comprehensiveness are important factors in determining the cause of dissatisfaction and correcting it.

Strategic Requirements

Strategic direction is received through two instruments in strategic requirements processing (SRP): mission operations capability (MOC) and quality function deployment (QFD). Through SRP, customers are able to accurately project their expectations to the receiving organization. This information is formal, specific, external, and powerful. The organization

must interpret the information properly and acknowledge that expectations are understood and accepted. A good way to accomplish this is through informal requirement processing meetings where cross-functional, multi-organizational teams meet and agree on the requirements of the customer and the producer. The requirements are documented on a requirements matrix, and are used throughout both organizations for design, producibility, process development, control, and validation.

The philosophy of SRP must pervade the organization, going beyond documenting the external customer's requirements. It can be effectively used within the organization to formally document strategic direction and the tactical implementation of strategic direction. Further, SRP is disseminated throughout the organization so that each process owner is aware of senior direction. Each organization formalizes a process that captures and focuses feedback. Various teams play an important part in this process. However, internal teams are better able to focus on immediate direction and determine where system problems will occur. Continuous review of process action team and process improvement team results provides immediate feedback that may alert process owners to unforeseen problems.

Many formal forums exist for documenting deviations and noncompliance. These include formal design reviews as the product matures along a development process. Requirements are initially reviewed at the systems requirements review (SRR), which ensures that all participants know the top-level requirements. This is where the customer's expectations must really be understood. SRRs are the foundation of all subsequent work. If there are problems with understanding expectations, this is the time to stop and correct them. If history repeats itself, it will cost much to make corrections later in the development process.

Subsequent reviews, such as systems design review, preliminary design review, critical design review, functional configuration audit, physical configuration audit, and production readiness review, play important roles in the formal direction/feedback process. In a total quality organization, however, they play a lesser role because requirements were well defined in the beginning and built upon as the design matured. The complete opposite is true for most US organizations today.

Suppliers

Suppliers have to be considered part of the organization and must be fully integrated into the direction/feedback system. As participants in PATs, suppliers understand the requirements being levied upon them, and they participate in a dialogue that is productive for all concerned. Through this informal direction/feedback system, suppliers function as honest brokers who can solve many problems between customer and producer. This can happen only if they are allowed to be equal participants, of course. The direction/feedback system cannot remain informal in all cases because of

contractual instruments between the customer, producer, and supplier. Some formal direction/feedback mechanisms are therefore necessary.

Formal direction and feedback should take two forms between the producer and supplier. The first is consistent with the contractual requirements for information distribution between the parties. The second is quick and simple to ensure that problems identified by PATs get to the supplier as fast as possible—that is, without layers and layers of contractual review. A significant amount of trust is required between all parties. This trust will not be present if the producing organization continues to use multiple suppliers for single requirements. Suppliers will take the risk if they know they are in for the duration and not just a quick in-and-out annual contract.

If trust is established between producer and supplier, there is no good reason why the supplier should not be fully integrated into the organization. Suppliers should receive direction and feedback through the same system the producer uses to provide direction to the tactical element and the same system the tactical element uses to provide direction to the programs and project element. Feedback should be no different. Direction and feedback to and from the supplier are part of the loop.

Customers

Customers provide direction and feedback to three elements in the direction/feedback loop: the strategic element, strategic requirements, and the Shewhart Cycle. The last two paths have already been discussed. The first and principal path is directly to the strategic element. Direction provided to the strategic element includes both positive and negative findings on past and present performances. Such information should also be quickly disseminated throughout the organization for process owners to determine opportunities to make corrections. Likewise, where customer satisfaction is acknowledged, this information should also be quickly distributed throughout the organization. When and where feasible, immediate replies are made to customer complaints.

Customers use their input to the producer's loop to influence the direction of the organization. Feedback on future intentions will better position the producer to be able to meet future expectations. Suggestions on areas of future research and development, plant locations, responsive employees, and strategic analysis, to mention but a few, assist the producing organization to meet future needs.

The producing organization can use customer feedback to affect strategic visioning, product diversification, plant expansion, and the like. By including customers in the internal operations of the organization via the direction/feedback loop, customers, much like process owners, become committed because they have a sense of ownership and affinity to the organization. When the organization's strategic goals are linked through a direction/feedback loop that includes all elements in the industrial process,

quality, productivity, and satisfaction are realized by the organization and its customers.

Total quality will be achieved only when all environmental elements are interconnected through a direction/feedback system that provides a quality super vision. A quality super vision that does not accept status quo but strives for excellence in every activity is the mark of an organization postured for success in the next century.

Notes

1. Robert D. Pritchard et al., *Enhancing Productivity through Feedback and Goal Setting*, AFHRL-TR-81-7 (Brooks AFB, Tex.: Manpower and Personnel Division, Human Resources Laboratory, July 1981), 6–8.

Appendix A

DOD POSTURE ON QUALITY*

- Quality is absolutely vital to our defense, and requires a commitment to continuous improvement by all DOD personnel.
- A quality- and productivity-oriented defense industry with its underlying industrial base is the key to our ability to maintain a superior level of readiness.
- Sustained DOD-wide emphasis and concern with respect to high quality and productivity must be an integral part of our daily activities.
- Quality improvement is a key to productivity improvement and must be pursued with the necessary resources to produce tangible benefits.
- Technology, being one of our greatest assets, must be widely used to improve continuously the quality of defense systems, equipments, and services.
- Emphasis must change from relying on inspection, to designing and building quality into the process and product.
- Quality must be a key element of competition.
- Acquisition strategies must include requirements for continuous improvement of quality and reduced ownership costs.
- Managers and personnel at all levels must take responsibility for the quality of their efforts.
- Competent, dedicated employees make the greatest contributions to quality and productivity. They must be recognized and rewarded accordingly.
- Quality concepts must be ingrained throughout every organization with the proper training at each level, starting with top management.
- Principles of quality improvement must involve all personnel and products, including the generation of products in paper and data form.

*Memorandum, US Secretary of Defense Frank C. Carlucci, DOD handbook on *Total Quality Management*, undated, inside front cover.

Appendix B

Dr Deming's Early Fourteen Obligations of Management*

1. Create constancy of purpose towards improving products and services, allocating resources to provide for long-range needs rather than short-term profitability.
2. Adopt the new philosophy for economic stability by refusing to allow commonly accepted levels of delays, mistakes, defective materials, and defective workmanship.
3. Cease dependence on mass inspection by requiring statistical evidence of built-in quality in both manufacturing and purchasing functions.
4. Reduce the number of suppliers for the same item by eliminating those that do not qualify with statistical evidence of quality. End the practice of awarding business solely on the basis of price.
5. Search continuously for problems in the system to constantly improve processes.
6. Institute modern methods of training to make better use of all employees.
7. Force supervision in helping people do a better job. Ensure that immediate action is taken on reports of defects, maintenance requirements, poor tools, inadequate operating definitions, or other conditions detrimental to quality.
8. Encourage effective two-way communication and other means to drive out fear throughout the organization and help people work more productively.
9. Break down barriers between departments by encouraging problem solving through teamwork, combining the efforts of people from different areas such as research, design, sales, and promotion.
10. Eliminate the use of numerical goals, posters, and slogans for the work force that ask for new levels of productivity without providing methods.
11. Use statistical methods for continuing improvement of quality and productivity, and eliminate work standards that prescribe numerical quotas.
12. Remove all barriers that inhibit the worker's right to pride of workmanship.
13. Institute a vigorous program of education and retraining to keep up with changes in materials, methods, product design, and machinery.
14. Clearly define top management's permanent commitment to quality and productivity and its obligation to implement all of these principles.

*House Republican Research Committee, Task Force on High Technology, Mickey Edwards, chairman, "Quality as a Means to Improving Our Nation's Competitiveness," 12 July 1988.

Appendix C

Typical Business Processes Where Process Control Can Be Applied*

Function	Process Name
Development	Records Management
	Acoustics Control Design
	Advanced Communication Development
	Cable Component Design
	Reliability Management
	Cost Target
	Design Test
	Design/Material Review
	Document Review
	High-Level Design Specification
	Industrial Design
	Interdivisional Liaison
	Logic Design and Verification
	Component Qualification
	Power System Design
	Product Management
	Product Publication
	Release
	System-Level Product Design
	System Reliability and Serviceability (RAS)
	System Requirements
	Tool Design
	User/System Interface Design
	Competitive Analysis
	Design Systems Support
	Engineering Operations
	Information Development
	Interconnect Planning
	Interconnect Product Development
	Physical Design Tools
	Systems Design
	Engineering Change Management
	Product Development
	Tool Development
	Development Process Control
	Electronic Development

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Function	Process Name
	Phase 0/Requirements
Distribution	Receiving Shipping Storage Field Services/Support Teleprocessing and Control Parts Expediting Power Vehicles Salvage Transportation Production Receipts Disbursement Inventory Management Physical Inventory Management
Financial Accounting	Ledger Control Financial Control Payroll Taxes Transfer Pricing Accounts Receivable Accrual Accounting Revenue Accounting Accounts Payable Cash Control Employee Expense Account Fixed Asset Control Labor Distribution Cost Accounting Financial Application Fixed Assets/Appropriation Intercompany/Accounting/Billing Inventory Control Procurement Support
Financial Planning	Appropriation Control Budget Control Cost Estimating Financial Planning Transfer Pricing Inventory Control Business Planning Contract Management Financial Outlook

Function	Process Name
Information Systems	Applications Development Methodology Systems Management Controls Service-Level Assessment
Production Control	Consignment Process Customer Order Services Management Early Manufacturing Involvement and Product Release Engineering Change (EC) Implementation Field Parts Support Parts Planning and Ordering Planning and Scheduling Management Plant Business Volumes Performance Management Site Sensitive Parts Systems Work in Process (WIP) Management Allocation Inventory Projection New Product Planning WIP Accuracy Base Plan Commit Manufacturing Process Record
Purchasing	Alteration/Cancellation Expediting Invoice/Payment Supplier Selection Cost Delivery Quality Supplier Relations Contracts Laboratory Procurement Nonproduction Orders Production Orders Supplier Payment Process Interplant Transfer
Personnel	Benefits Compensation Employee Relations Employment Equal Opportunity Executive Resources Management Development

Function	Process Name
	Medical Personnel Research Personnel Services Placement Records Suggestions Management Development/Research Personnel Programs Personnel Assessment Resource Management
Programming	Distributed Systems Products Programming Center Software Development Software Engineering Software Manufacturing Products
Quality	New Product Qualification Supplier Quality
Site Services	Facilities Change Request
Miscellaneous	Cost of Box Manufacturing Quality Service Cost Estimating Site Planning

Typical Output Measurements

I. Accounting Quality Measurements

1. Percent of late reports
2. Percent of errors in reports
3. Errors in input to Information Services
4. Errors reported by outside auditors
5. Percent of input errors detected
6. Number of complaints by users
7. Number of hours per week [spent] correcting or changing documents
8. Number of complaints about inefficiencies or excessive paper
9. Amount of time spent appraising/correcting input errors
10. Payroll processing time
11. Percent of errors in payroll
12. Length of time to prepare and send a bill
13. Length of time billed and not received
14. Number of final accounting jobs rerun
15. Number of equipment sales miscoded
16. Amount of intracompany accounting bill-back activity
17. Time spent correcting erroneous inputs
18. Number of open items
19. Percent of deviations from cash plan
20. Percent of discrepancy in Material Review Board (MRB) and line scrap reports
21. Travel expense accounts processed in three days
22. Percent of advances outstanding
23. Percent of data entry errors in accounts payable and general ledger
24. Credit turnaround time
25. Machine billing turnaround time
26. Percent of shipments requiring more than one attempt to invoice
27. Number of untimely supplier invoices processed
28. Average number of days from receipt to processing

II. Clerical Quality Measurements

1. Misfiles per week
2. Paper mailed/paper used
3. Errors per typed page
4. Administration errors (not using the right procedure)
5. Number of times manager is late to meetings
6. Number of times messages are not delivered
7. Percent of action items not done on schedule

8. Percent of inputs not received on schedule
9. Percent of coding errors on time cards
10. Period reports not completed on schedule
11. Percent of phone calls answered within two rings
12. Percent of phone calls dialed correctly
13. Pages processed error-free per hour
14. Clerical personnel/personnel supported
15. Percent of pages retyped
16. Percent of impressions reprinted

III. Product/Development Engineering Quality Measurements

1. Percent of drafting errors per print
2. Percent of prints released on schedule
3. Percent of errors in cost estimates
4. Number of times a print is changed
5. Number of off-specs approved
6. Simulation accuracy
7. Accuracy of advance materials list
8. Cost of input errors to the computer
9. How well product meets customer expectations
10. Field performance of product
11. Percent of error-free designs
12. Percent of errors found during design review
13. Percent of repeat problems corrected
14. Time to correct a problem
15. Time required to make an engineering change
16. Cost of engineering changes per month
17. Percent of reports with errors in them
18. Data recording errors per month
19. Percent of evaluations that meet engineering objectives
20. Percent of special quotations that are successful
21. Percent of test plans that are changed (change/test plan)
22. Percent of meetings starting on schedule
23. Spare parts' cost after warranty
24. Number of meetings held per quarter where quality and defect prevention were the main subject
25. Person-months per released print
26. Percent of total problems found by diagnostics as released
27. Customer cost per life of output delivered
28. Number of problems that were also encountered in previous products
29. Cycle time to correct a customer problem
30. Number of errors in publications reported from the plant and field
31. Number of products that pass independent evaluation error free
32. Number of missed shipments of prototypes

33. Number of unsuccessful preanalyses
34. Number of off-specs accepted
35. Percent of requests for engineering action open for more than two weeks
36. Number of days late to preanalysis
37. Number of restarts of evaluations and test
38. Effectiveness of regression tests
39. Number of days for the release cycle
40. Percent of corrective action schedules missed
41. Percent of bills of material that are released in error

IV. Finance Quality Measurements

1. Percent of error in budget predictions
2. Computer rerun time due to input errors
3. Computer program change cost
4. Percent of financial reports delivered on schedule
5. Number of record errors per employee
6. Percent of error-free vouchers
7. Percent of bills paid so company gets price break
8. Percent of errors in checks
9. Entry errors per week
10. Number of payroll errors per month
11. Number of errors found by outside auditors
12. Number of errors in financial reports
13. Percent of errors in travel advancement records
14. Percent of errors in expense accounts detected by auditors

V. Industrial/Plant Engineering

1. Percent of facilities on schedule
2. Percent of manufacturing time lost due to bad layouts
3. Percent of error in time estimates
4. Percent of error in purchase requests
5. Hours lost due to equipment downtime
6. Scrap and rework due to calibration errors
7. Repeat call hours for the same problem
8. Changes to layout
9. Percent of deviation from budget
10. Maintenance cost/equipment cost
11. Percent of variation to cost estimates
12. Number of unscheduled maintenance calls
13. Number of hours used on unscheduled maintenance
14. Number of hours used on scheduled maintenance
15. Percent of equipment maintained on schedule
16. Percent of equipment overdue for calibration
17. Accuracy of assets report

18. Percent of total floor space devoted to storage
19. Number of industrial design completions past due
20. Number of mechanical/functional errors in industrial design artwork
21. Number of errors found after construction had been accepted by the company
22. Percent of engineering action requests accepted

VI. Forecasting Quality Measurements

1. Number of upward pricing revisions per year
2. Number of project plans that meet schedule, price, and quality [requirements]
3. Percent of error in sales forecasts
4. Number of forecasting assumption errors
5. Number of changes in product schedules

VII. Information Systems Quality Measurements

1. Keypunch errors per day
2. Input correction on CRT
3. Reruns caused by operator error
4. Percent of reports delivered on schedule
5. Errors per thousand lines of code
6. Number of changes after the program is coded
7. Percent of time required to debug programs
8. Rework costs resulting from computer program
9. Number of cost estimates revised
10. Number of errors in forecast
11. Percent of errors in lines of code required
12. Number of coding errors found during formal testing
13. Number of test case errors
14. Number of test case runs before success
15. Number of revisions to plan
16. Number of documentation errors
17. Number of revisions to program objectives
18. Number of errors found after formal test
19. Number of error-free programs delivered to customer
20. Number of process step errors before a correct package is ready
21. Number of revisions to checkpoint plan
22. Number of changes to customer requirements
23. Percent of programs not flow diagramed
24. Percent of customer problems not corrected per scheduled
25. Percent of problems uncovered before design release
26. Percent change in customer satisfaction survey
27. Percent of defect-free artwork
28. System availability

29. Terminal response time
30. Mean time between system initial program loadings (IPL)
31. Mean time between system repairs
32. Time before help calls are answered

VIII. Legal Quality Measurements

1. Response time on request for legal opinion
2. Time to prepare patent claims
3. Percent of cases lost

IX. Management Quality Measurements

1. Security violations per year
2. Percent of variation from budget
3. Percent of target dates missed
4. Percent of personnel turnover rate
5. Percent of increase in output per employee
6. Percent of absenteeism
7. Percent of error in planning estimates
8. Percent of output delivered on schedule
9. Percent of employees promoted to better jobs
10. Department morale index
11. Percent of meetings that start on schedule
12. Percent of employee time spent on first-time output
13. Number of job improvement ideas per employee
14. Dollars saved per employee due to new ideas and/or methods
15. Ratio of direct to indirect employees
16. Increased percent of market
17. Return on investment
18. Percent of appraisals done on schedule
19. Percent of changes to project equipment required
20. Normal appraisal distribution
21. Percent of employee output that is measured
22. Number of grievances per month
23. Number of open doors per month
24. Percent of professional employees active in professional societies
25. Percent of managers active in community activities
26. Number of security violations per month
27. Percent of time program plans are met
28. Improvement in opinion surveys
29. Percent of employees who can detect and repair their own errors
30. Percent of delinquent suggestions
31. Percent of documents that require two management signatures
32. Percent of error in personnel records

33. Percent of time cards signed by managers that have errors on them
34. Percent of employees taking higher education
35. Number of damaged equipment and property reports
36. Warranty costs
37. Scrap and rework costs
38. Cost of poor quality
39. Number of employees dropping out of classes
40. Number of decisions made by higher-level management than required by procedures
41. Improvement in customer satisfaction survey
42. Volumes actual versus plan
43. Revenue actual versus plan
44. Number of formal reviews before plans are approved
45. Number of procedures with fewer than three acronyms and abbreviations
46. Percent of procedures less than 10 pages
47. Percent of employees active in improvement teams
48. Number of hours per year of career and skill development training per employee
49. Number of user complaints per month
50. Number of variances in capital spending
51. Percent revenue/expense-ratio below plan
52. Percent of executive interviews with employees
53. Percent of departments with disaster recovery plans
54. Percent of appraisals with quality as a line item that makes up more than 30 percent of the evaluation
55. Percent of employees with development plans
56. Revenue generated over strategic period
57. Number of iterations of strategic plan
58. Number of employees participating in cost-effectiveness
59. Data integrity
60. Result of peer reviews
61. Number of tasks for which actual time exceeded estimated time

X. Manufacturing and Test Engineering Quality Measurements

1. Percent of process operations where sigma limit is within engineering specification
2. Percent of tools that fail certification
3. Percent of tools reworked due to design errors
4. Number of process changes per operation due to errors
5. In-process yields
6. Percent of errors in manufacturing costs
7. Time required to solve a problem
8. Number of delays because process instructions are wrong or not available

9. Labor utilization index
10. Percent of errors in test equipment and tooling budget
11. Number of errors in operator training documentation
12. Percent of errors that escape the operator's detection
13. *Percent of testers that fail certification*
14. Percent of errors in yield projections
15. Percent of errors in output product quality
16. Asset utilization
17. Percent of designed experiments needing revisions
18. Percent of changes to process specifications during process design review
19. Percent of equipment ready for production on schedule
20. Percent of meetings starting on schedule
21. Percent of drafting errors found by checkers
22. Percent of manufacturing used to screen products
23. Number of problems that the test equipment cannot detect during manufacturing cycle
24. Percent of correlation between testers
25. Number of waivers to manufacturing procedures
26. Percent of tools and test equipment delivered on schedule
27. Percent of tools and test equipment on change level control
28. Percent of functional test coverage of products
29. Percent of projected cost reductions missed
30. Percent of action plan schedules missed
31. Equipment utilization

XI. Manufacturing/Shipping Quality Measurements

1. Complaints on shipping damage
2. Percent of parts not packed to required specifications
3. Percent of output that meets customer orders and engineering specifications
4. Scrap and rework cost
5. Suggestions per employee
6. Percent of jobs that meet cost
7. Percent of jobs that meet schedule
8. Percent of product defect-free at measurement operations
9. Percent of employees trained to do the job they are working on
10. Accidents per month
11. Performance against standards
12. Percent of utilities left improperly running at end of shift
13. *Percent of unplanned overtime*
14. Number of security violations per month
15. Percent of time logbook filled out correctly
16. Time and/or claiming errors per week
17. Time between errors at each question

18. Errors per 100,000 solder connections
19. Labor utilization index
20. Percent of operators certified to do their job
21. Percent of shipping errors
22. Defects during warranty period
23. Replacement parts defect rates
24. Percent of products defective at final test
25. Percent of control charts maintained correctly
26. Percent of invalid test data
27. Percent of shipments below plan
28. Percent of daily reports in by 7:00 A.M.
29. Percent of late shipments
30. Percent of products error-free at final test

XII. Marketing Quality Measurements

1. Percent of proposals submitted ahead of schedule
2. Cost of sales per total costs
3. Percent of errors in market forecasts
4. Percent of proposals accepted
5. Percent of quota attained
6. Response time to customer inquiries
7. Inquiries per $10,000 of advertisement
8. Number of new customers
9. Percent of repeat orders
10. Percent of time customer expectations are identified
11. Sales made per call
12. Errors in orders
13. Ratio of marketing expenses to sales
14. Number of new business opportunities identified
15. Errors per contract
16. Percent of time customer expectation changes are identified before they impact sales
17. Man-hours per $10,000 sales
18. Percent reduction in residual inventory
19. Percent of customers called back as promised
20. Percent of meetings starting on schedule
21. Percent of changed orders
22. Number of complimentary letters
23. Percent of phone numbers correctly dialed
24. Time required to turn in travel expense accounts
25. Number of revisions to market requirements statements per month
26. Percent of bids returned on schedule

27. Percent of customer letters answered in two weeks
28. Number of complaint reports received
29. Percent of complaint reports answered in three days

XIII. Personnel Quality Measurements

1. Percent of employees who leave during the first year
2. Number of days to answer suggestions
3. Number of suggestions resubmitted and approved
4. Personnel cost per employee
5. Cost per new employee
6. Turnover rate due to poor performance
7. Number of grievances per month
8. Percent of employment requests filled on schedule
9. Number of days to fill an employment request
10. Management evaluation of management education courses
11. Time to process an applicant
12. Average time a visitor spends in lobby
13. Time to get security clearance
14. Time to process insurance claims
15. Percent of employees participating in company-sponsored activities
16. Opinion survey ratings
17. Percent of complaints about salary
18. Percent of personnel problems handled by employees' managers
19. Percent of employees participating in voluntary health screening
20. Percent of offers accepted
21. Percent of retirees contacted yearly by phone
22. Percent of training classes evaluated excellent
23. Percent deviation to resource plan
24. Wait time in medical department
25. Number of days to respond to applicant
26. Percent of promotions and management changes publicized
27. Percent of error-free newsletters

XIV. Procurement/Purchasing Quality Measurements

1. Percent of discount orders by consolidating
2. Errors per purchase orders
3. Numbers of orders received with no purchase order
4. Routing and rate errors per shipment
5. Percent of supplies delivered on schedule
6. Percent decrease in parts costs
7. Expeditors per direct employees
8. Number of items on the hot list
9. Percent of suppliers with 100 percent lot acceptance for one year
10. Stock costs

11. Labor hours per $10,000 purchases
12. Purchase order cycle time
13. Number of times per year line is stopped due to lack of supplier parts
14. Supplier parts scrapped due to engineering changes
15. Percent of parts with two or more suppliers
16. Average time to fill emergency orders
17. Average time to replace rejected lots with good parts
18. Parts cost per total costs
19. Percent of lots received on line late
20. Actual purchased materials cost per budgeted cost
21. Time to answer customer complaints
22. Percent of phone calls dialed correctly
23. Percent of purchase orders returned due to errors or incomplete description
24. Percent of defect-free supplier model parts
25. Percent projected cost reductions missed
26. Time required to process equipment purchase orders
27. Cost of rush shipments
28. Number of items billed but not received

XV. Production Control Quality Measurements

1. Percent of late deliveries
2. Percent of errors in stocking
3. Number of items exceeding shelf life
4. Percent of manufacturing jobs completed on schedule
5. Time required to incorporate engineering changes
6. Percent of errors in purchase requisitions
7. Percent of products that meet customer orders
8. Inventory turnover rate
9. Time that line is down due to assembly shortage
10. Percent of time parts are not in stock when ordered from common parts crib
11. Time product in shipment
12. Cost of rush shipments
13. Spare parts availability in crib
14. Percent of errors in work-in-process records versus audit data
15. Cost of inventory spoilage
16. Number of bill-of-lading errors not caught in shipping

XVI. Quality Assurance Quality Measurements

1. Percent of errors in reliability projections
2. Percent of product that meets customer expectations
3. Time to answer customer complaints
4. Number of customer complaints

5. Number of errors detected during design and process reviews
6. Percent of employees active in professional societies
7. Number of audits performed on schedule
8. Percent of quality assurance personnel to total personnel
9. Percent of quality inspectors to manufacturing directs
10. Percent of quality inspectors to manufacturing engineers
11. Number of engineering changes after design review
12. Number of process changes after process qualification
13. Errors in reports
14. Time to correct a problem
15. Cost of scrap and rework that was not created at the rejected operation
16. Percent of suppliers at 100 percent lot acceptance for one year
17. Percent of lots going directly to stock
18. Percent of problems identified in the field
19. Variations between inspectors doing the same job
20. Percent of reports published on schedule
21. Number of complaints from manufacturing management
22. Percent of field returns correctly analyzed
23. Time to identify and solve problems
24. Percent of laboratory services not completed on schedule
25. Percent of improvement in early detection of major design errors
26. Percent of errors in defect records
27. Number of reject orders not dispositioned in five days
28. Number of customer calls to report errors
29. Level of customer surveys
30. Number of committed supplier plans in place
31. Percent of correlated test results with suppliers
32. Receiving inspection cycle time
33. Number of requests for corrective action being processed
34. Time required to process a request for corrective action
35. Number of off-specs approved
36. Percent of part numbers going directly to stock
37. Number of manufacturing interruptions caused by supplier parts
38. Percent of error in predicting customer performance
39. Percent of product cost related to appraisal, scrap, and rework
40. Percent of skip lot inspection
41. Percent of qualified suppliers
42. Number of problems identified in-process

XVII. Security/Safety Quality Measurements

1. Percent of clearance errors
2. Time to get clearance
3. Percent of security violations

4. Percent of documents classified incorrectly
5. Security violations per audit
6. Percent of audits conducted on schedule
7. Percent of safety equipment checked per schedule
8. Number of safety problems identified by management versus total safety problems identified
9. Safety accidents per 100,000 hours worked
10. Safety violations by department
11. Number of safety suggestions
12. Percent of sensitive parts located

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